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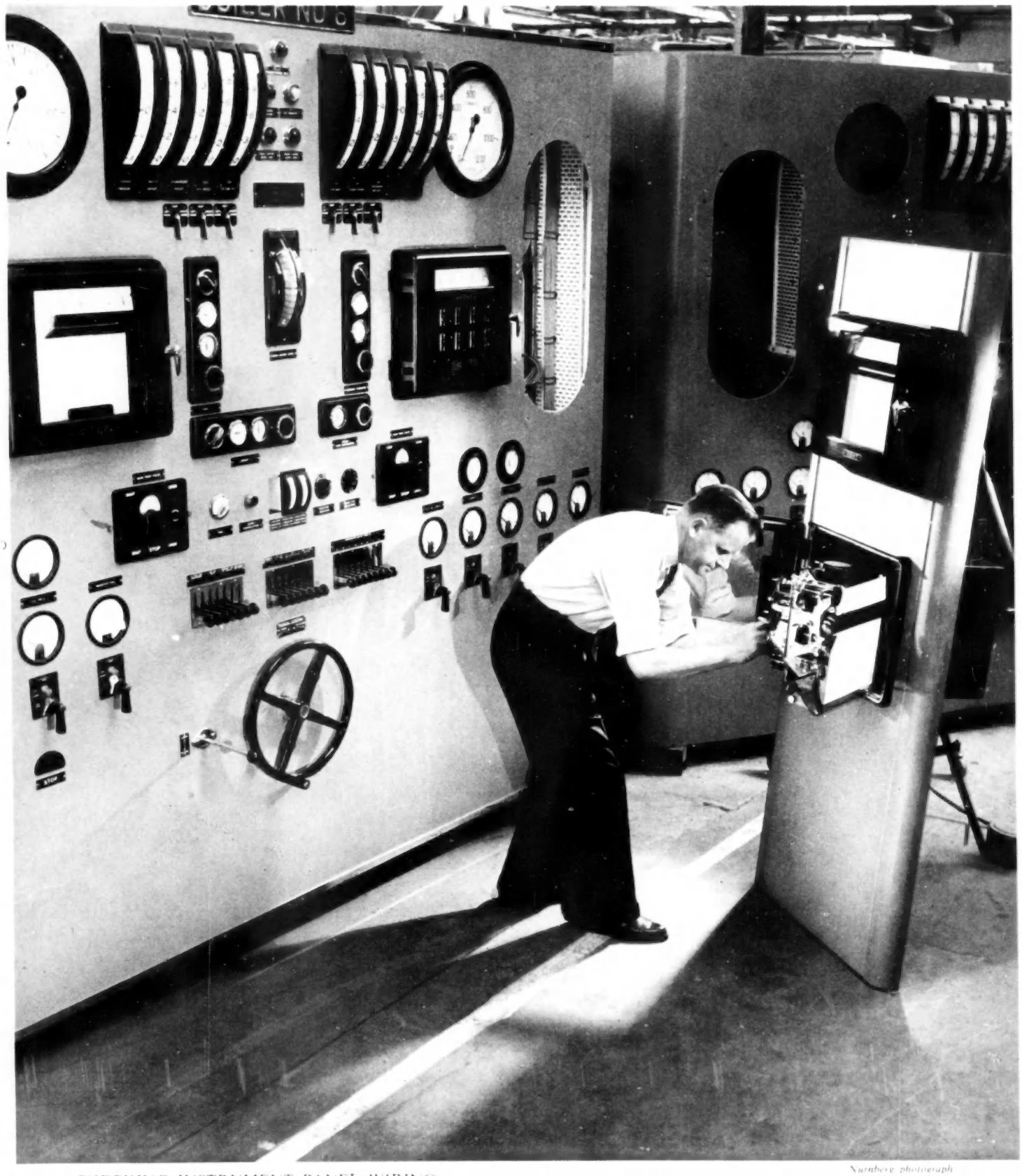

CHECKING INSTRUMENT PANEL WIRING

Nuenberg photograph for ENGINEERING

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HUMAN ELEMENTS

It may be useful to give a brief review of the detailed information which Mr. Murrell has provided in his valuable articles on human performance for engineering designers. They have been published in five recent issues of ENGINEERING—the last is on page 438 of this issue—but not everyone who is interested in this aspect of design will have had time to read them.

Many of the points he has made, taking them separately, seem obvious enough. Indeed, they are obvious when they are stated in cold print. But it is necessary to state them because there are so many points to watch in designing equipment for human use that some of them are bound to be overlooked if they are not set out in a logical fashion. In addition, there are many psychological principles, of comparatively recent discovery, which are not generally known. A competent designer is apt to think that he has no need of these refinements —after all, he is a human being himself, able to understand the physical and visual requirements of other human beings—but the fact is that we know extraordinarily little about ourselves and the mechanics of our minds and bodies. What we do know is usually only in a general, not to say vague form, lacking quantitative values that can be applied in designing. That designers to-day fail to produce designs which are wholly satisfactory from the human point of view is apparent to any discriminating observer.

Visual displays take the forms of dials, counters, or indicators. If they are well designed they look deceptively simple, but much care is required to produce the best result. The fundamental approach is to decide exactly what information is required by the operator and then choose and design the displays to give just that information in the simplest possible form. Thus, for example, the roadman using a pneumatic drill is not interested in the pressure at which the compressor is operating; he only needs to know whether the pressure is above a minimum or below a maximum. This requirement can be met by a very simple gauge dial without the use of numbers. Some of the points to watch in visual display design generally are: certain advantages which horizontal linear dials have over circular or vertical linear types; the pros and cons of moving pointers and moving scales; the effects on each dial when several dials are arranged in close proximity; and the advantages of direct-reading counters over dials and pointers when a quantitative value alone is to be indicated. The design of satisfactory dial faces is quite a subtle business. A British Standard is being prepared on the subject but meanwhile Mr. Murrell gives guidance to designers. Typical of the points which have to be considered are the size of the dial, the distance at which it has to be read, the spacing of the scale marks, the degree of accuracy to which they have to be read, the extent to which the observer has to interpolate, the length of the pointer, the effect of surrounding parts, and the inter-relation of all these factors on each other. Such a comprehensive view of design has certainly not been taken in the case of some motor-car fascias and controls.

From displays to controls—and here we are concerned more with the physical characteristics and powers of the body. The most convenient speed at which a crank control can be turned, the torque which can be applied to it, the most convenient diameter of throw, the size and shape of the handle, the plane in which the crank is turned—these are some of the features of crank controls which have to be considered. Handwheels are chosen when slow turning speeds are required, when accurate partial turns are to be executed, and when the load is too great for a knob operated by one hand. Knobs should be used for making fine adjustments when loads are light, and for some switching operations. Levers are suitable when the effective travel is short, when speed of movement and not accuracy is required, when the load is medium to heavy, and when rapid switching with or without a load is desired. A joystick, being a two-dimensional lever, offers a greater range of control, but its design is not one of the more obvious branches of this subject; Mr. Murrell suggests that a vertical stick is preferable to a horizontal stick, and that a vertical stick with the free end down and held in the fingers like a pencil is superior to a stick with the free end up. The remaining important type of control is the pedal; it is used when a powerful force is required, for continuous controlling without a high degree of accuracy, and for on-off or start-stop switching. A seated operator can exert forces up to 700 lb. on a pedal, but much less than this is usual.

Much can be done for operators, too, by improved control of environmental conditions such as heat, noise, lighting and the choice of suitable colours. Noise is a particularly interesting factor because the results of research into the effects of noise are to some extent contradictory. It may be that in this and other aspects of design of equipment for human use, the time has come for engineers to join psychologists and others so as to advance our understanding. The sad thing, in many ways, is that the more progress is made in this field, the less manual skill is required. Skill goes into design and is taken out of operation.

Cover Picture: *With modern instrument panels, operators can read off the value of selected variables at any stage in an industrial process. As plant design and automatic processes develop, so comprehensive instrument and automatic control panels become increasingly complex. The illustration shows the wiring inside a controlling instrument on a relatively simple two-instrument panel being checked.*

* * *

Plain Words

Executive ailments have lately been the subject of many warnings and much good advice. Duodenal suppuration has been described in vivid if not glowing colours, and six-month vacations recommended. A more realistic though less dramatic treatment has been prescribed by B.E.A.M.A. This year the British Electrical and Allied Manufacturers' Association have decided to cancel their annual dinner, and so relieve the pressure on that score or two of busy men whose services as after-dinner speakers are so much in demand.

Night after night—assisted no doubt by their long-suffering wives—these men ease themselves into clothes characterised by discomfort and inconvenience, secure a galaxy of buttons, studs, flaps, loops and even pins, and ponder once more what is to be done with the loose end of a white tie. At the same time they pray their audience will not have heard the one about the garrulous Armenian, and feverishly prepare a second set of anecdotes in case there are ladies present. They are being driven literally to drink.

When eventually they take their places, their digestive systems will be inhibited by the knowledge that a merciless man in a red coat may at any moment bellow suddenly and fiercely just behind their backs. They sip their drinks temperately, knowing that their faculties must be retained in crystal-clear condition for the moment they are called upon to speak. The notes they have prepared seem desperately inadequate; words have vanished from their heads, like facts from the mind of an examination candidate; there are knots in their stomachs and a dryness on their lips; the Rennies in their ticket pockets are beginning to crumble. Yet to-morrow they must be fresh and decisive.

Perhaps this is an inflated picture—few of us dine out every night, and when occasionally we are lucky enough to receive an invitation, or attend the dinner of a body to which we belong, it is almost always with pleasure: good food well served, lively conversation and stimulating views from the top table. B.E.A.M.A.'s decision represents, perhaps, a far more serious gesture. Made on the day the rise in Bank Rate was announced, it contains that very element of self-denial which is necessary to defeat inflation. It will also enable B.E.A.M.A. to concentrate on their creditable effort—which might profitably be imitated—to bring Britain's goods before the world's eye at next year's Brussels Fair. This, too, may help in conquering inflation. Whatever seams are opened up, inflation can never be concealed beneath a dinner jacket.

ORIGIN OF THE FOOT-MEASURE

MEASURES OF LENGTH SINCE THE TOWER OF BABEL

By C. St. C. Davison, M.SC., PH.D.

Recently the Science Museum at South Kensington, London, celebrated its centenary, and in recognition of that event we publish below an article by Dr. C. St. C. Davison, who is Assistant Keeper in charge of the Museum's Metrology Collection. Measurement is fundamental to science and it is appropriate that the article should have measures of length as its subject. Many valuable historic measures of length—some real and some copies—from the Third Millenium B.C. *to the present day are on display at the Science Museum. The article is the fourth in a series prepared for* ENGINEERING *by Dr. Davison, outlining the historical development of various items of engineering interest. Previous articles have dealt with gears (vol.* 181, *page* 133, 1956), *the internal combustion engine (vol.* 182, *page* 258, 1956), *and bearings (vol.* 183, *page* 2, 1957). *Current interest in the early history of measurement is underlined by an educational display on the history of measurement standards set up by the General Motors Corporation at their Indiana plant; the display includes replicas of standards from the Egyptian royal cubit to the present metre bar. The Wilkie Foundation, Illinois, have also given prominence to this aspect of history.*

When man had reached a certain stage in evolution he found it necessary to convey impressions of size. Thus he naturally described a piece of wood as being as long as his arm, or an amber ornament as thick as his finger. We do not know when this occurred but it is obvious that he constantly felt the urge to better himself and by so doing reached another stage when it was necessary to be more precise. The length of the forearm from the point of the elbow to the tip of the middle finger, later known as a cubit, then became a standard measure; the span and the widths of the palm and the finger were regarded as proportions of the cubit. But this system of measurement had a drawback, since men varied in size both between one another and between different tribes.

Science Museum

Fig. 1 Mural tablet defining the British Imperial standards of length (1893). Such tablets were built into the walls of important buildings.

Consequently leaders of communities started to insist on the measures being marked off on wood or stone for general use and as a result standards of length thus made were built into the most conspicuous walls of churches and other edifices. Some inlaid castings (1876), similar to that in Fig. 1, with British Imperial standards of length have been preserved to this day on the first wall north of Nelson's column in Trafalgar Square, London. This practice tended to increase accuracy and also to prevent arguments between tradesmen.

EARLY MEASURING-RODS

A fragment of a shell measuring-rod of approximately 3000 B.C., as shown in Fig. 2, was found at Mohenjo-Daro near the river Indus in Northern India where there was once a civilisation responsible for several large cities and excellent stone buildings. In Fig. 3 the Moon-God can be seen sitting on the right with a double-cubit rod and a roll of measuring-cord in his hand, listening to King Ur-Nammu before the construction (about 2100 B.C.) of a temple on a ziggurat which, when finally erected, became known as the Tower of Babel (or Babylon).

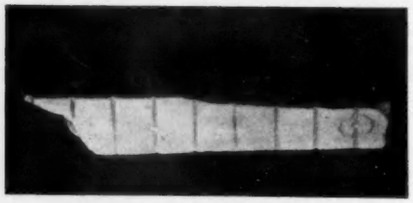


Fig. 2 Fragment from a measure of length from Mohenjo-Daro near the River Indus in northern India (*circa* 3000 B.C.).

The art of measuring was probably conveyed from Persia or northern India to Babylonia, where, as we know, there was another early civilisation with several cities. Babylonia, which was called Sumer and Akkad in cuneiform inscriptions, was for many centuries governed by the Sumerians up till an invasion from Gutium, about 2200 B.C., when they were overthrown. Gudéa, Prince of Lagash, became a ruler during the supremacy of the Guti (*circa* 2130 B.C.). A number of beautiful green-stone statues were made to commemorate him, and two of them portrayed him acting as an architect with a drawing-tablet on his knees, as in Fig. 4. A ground-plan for a building was drawn on one of the tablets upon each of which rested a drawing-implement and a calibra-

Fig. 3 Ur-Nammu, King of Ur, seeks consent from the Moon-God to build the Ziggurat of Ur. A ziggurat was a structure similar to a stepped pyramid and the Tower of Babel was in fact an edifice of this kind. The Moon-God holds out a double-cubit rod and a land-measuring cord in his right hand (*circa* 2100 B.C.).

Archives Photographiques, Paris

Fig. 4 (left) Headless statue of Gudéa, Prince of Lagash, showing a drawing tablet upon which rests a measuring rule and a drawing instrument (*circa* 2130 B.C.).

Science Museum

Fig. 5 (right) Part of an Egyptian royal cubit rod made of grey basalt (*circa* 2600 B.C.).

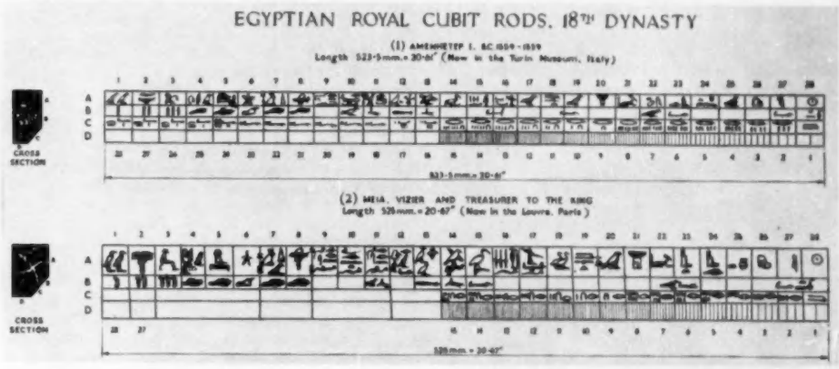

EGYPTIAN ROYAL CUBIT RODS. 18TH DYNASTY
(1) AMENHOTEP I. BC 1559-1539
Length 523·5 mm. = 20·6" (Now in the Turin Museum, Italy)
CROSS SECTION
(2) MEIA, VIZIER AND TREASURER TO THE KING
Length 529 mm. = 20·82" (Now in the Louvre, Paris)
CROSS SECTION

Fig. 6 Two Egyptian royal cubit rods made from Sudanese hardwood and inscribed with 28 digits—each of one finger's breadth (*circa* 1540 B.C.).

ted rule with the earliest record of a Sumerian cubit. These statues are now preserved in the Louvre in Paris but unfortunately all but one have no heads.

A portion of a picturesque stone cubit-rod, made in Egypt about 2600 B.C., is shown in Fig. 5. The rod was made with a bevelled front face and was marked in digits, these being progressively sub-divided into from two equal parts to ten. This cubit was an Egyptian royal cubit and its average length was 20·8 in.

EXPANDING CIVILISATIONS NEEDED GREATER PRECISION

Weapons, household appliances, jewellery and ornaments of all kinds, were made of bronze and more accurate workmanship was required as time went on. There is evidence that the technique of working copper was known, probably in eastern Persia, about 3500 B.C. and by about 3000 B.C. the Egyptians had developed a wide range of tools capable of making the finest joinery. The discovery of copper and of bronze led to developments of far-reaching importance. It caused an expansion of civilisation in the Middle East and remarkable migrations of peoples, who, in search of copper, went from country to country disseminating their knowledge of mining methods and science. The invention of metal tools so stimulated the Egyptian craftsmen that they created for their rulers some of the vastest monuments the world had ever known: pyramids and temples served as examples of what could be done in the practical field and inspired further developments. It was evident that accurate measurement was essential in the building of such grand structures.

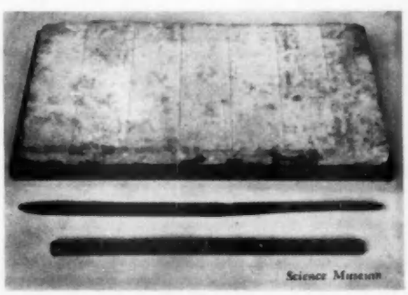
Fig. 6 shows how the Egyptian royal cubit-rods of about 1540 B.C. were marked out. Both rods were made of hardwood from the Sudan and inscribed with 28 digits—a digit being one finger's breadth—and directions in hieroglyphics describing other divisions of the cubit. The first 15 digits from the right were progressively subdivided into from 2 to 16 parts. The use of a cord for land-measuring in Egypt in about 1400 B.C. is illustrated in Fig. 7.

PALMS AND DIGITS

In the Sixth Century B.C. the Assyrians had a wooden cubit, as shown in Fig. 8, which was divided into six palms, each alternate palm being subdivided into four digits. Its front had a central division to indicate two Eastern Feet. The overall length of this rod was 21·05 in. although it has been found from records and from calculations from buildings to lie between 21·37 and 21·6 in. Both as a cubit and foot-

Science Museum

Fig. 7 Early land measuring in Egypt, showing the use of a cord divided by knots and comparable to the surveyor's chains employed to-day (*circa* 1400 B.C.).



Science Museum

Fig. 8 (above) Top to bottom: northern cubit marked on an Egyptian stone slab (*circa* First Century B.C.); Egyptian wooden cubit (*circa* 2000 B.C.); and Assyrian wooden cubit (Sixth Century B.C.).

Science Museum

Fig. 9 (right) Graeco-Roman marble notice addressed to trespassers. So that the potential trespasser might have no doubts about the limits within which trespass was forbidden an Olympic foot was added at the bottom (*circa* 350 A.D.).

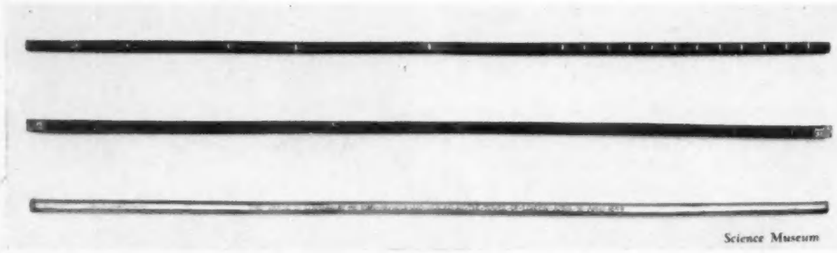


Fig. 10 Top to bottom: standard yard-bar of Henry VII (1497); standard yard-bar of Elizabeth I (1588); and Tower-of-London yard-bar (1659).

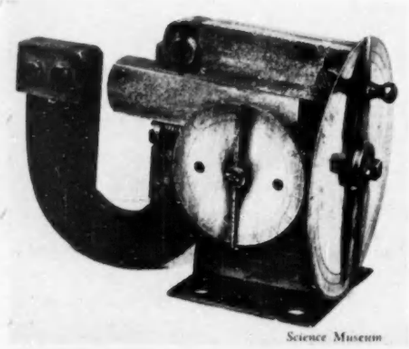


Fig. 11 James Watt's micrometer was graduated according to a yard-measure authorised by Queen Elizabeth I, and was constructed to read to 1/1,800 in. (*circa* 1772).

measure it was a very widespread unit and has been traced to the following regions: Assyria (21·37 in.), Persia (21·375 in.), Egypt (21·4 in.), Italy (21·375 in.), France (21·32 in.), England (21·48 in.), and Scotland (21·34 in.).

FROM GREECE TO FRANCE

The success of the Roman Empire and general increase of trade led to more settled conditions and standards for measurement became even more important. Fig. 8 shows an Egyptian standard cubit marked out on limestone (First Century B.C.). The cubit was accurately subdivided into seven palms by six vertical lines; its value averaging 26·8 in. This cubit was retained in Egypt as a cloth-measure known as the Cloth Pic up to the Nineteenth Century.

A Graeco-Roman marble notice with a foot-measure inscribed on it is shown in Fig. 9. The notice reads: ". . . the most sublime and righteous Lord of the whole inhabited world has decreed that no one is permitted to sow or trespass on the land within 15 feet on each side of this aqueduct. . . . But if anyone attempts to do this, he is liable to the capital penalty and confiscation of his property. This foot measure is appended to this notice." The foot-measure was 12·17 in. long and was known as the Greek Olympic Foot; it was usually employed in agriculture. Notices similar to this one were placed along the course of the Roman stone-pipe aqueduct for supplying drinking water to Jerusalem, built under Pontius Pilate, A.D.30.

Many countries reverted to more primitive measures when the Romans left them. Thus, for instance, the Saxons in England had a measure consisting of 3 barleycorns to 1 thumb (1·1 in.), 3 thumbs to 1 palm (3·3 in.), 4 palms to 1 Saxon foot (13·2 in.). Grains were not, however, very satisfactory as a basis for a measuring system; they varied in size according to whether they were taken from the inside of the ear or from the outside, and were subject to variation under different conditions of heat and humidity. The Chinese had a similar system many years earlier.

After the fall of the Roman Empire the Arabs continued to pursue the arts and sciences, and some of the better standards were brought back by them to Europe. Charlemagne (A.D. 771 to 814) was thought to have received a cubit, which was derived from that of Darius the Great, King of Persia, Assyria, and Egypt (521 to 435 B.C.), which in its turn was derived from the Assyrian cubit mentioned above. Half of this cubit became what was called the *pied du roi* and remained the official French foot until replaced by the metric system during the Revolution (1791). As early as 1670 many French people desired a standard of length established upon a firm basis. Thus the metre was taken as the one ten-millionth part of a meridional quadrant of the earth, and geodetic measurements to obtain this value were made on the meridian passing through Dunkirk and close to Barcelona.

EARLY ENGLISH MEASURES

Although reverting to the length of the barleycorn as a standard, the Saxons still clung to the Northern Foot for measuring land. This foot, at 13·2 in., can be traced back through various countries to the time when it was employed in early Babylonia for the same purpose. Measuring had, however, degenerated in most parts of Europe and the concept of correct measurement was not very strong; thus there were many units of length for different trades. In spite of the wishes of their rulers, the people preferred to retain their own different units. Iron yard-bars were apparently made under King John but they were not subdivided into inches because the inch was still governed by the length of a barley-corn. This state of affairs continued for many years. King Edward I made an iron *ulna* in 1305, which measured nearly 36 in. and was subdivided into 3 feet, each of nearly 12 inches (*ulna* was the early name for yard). Henry VII made a strong effort, like all the kings before him, to reform existing systems of measurement, and he obtained a new standard yard (1497) which was similar to King Edward's (see Fig. 10). Queen Elizabeth I authorised another reference-yard which remained in use as a standard until 1824. By that time, however, it was in a poor state; sometime earlier, it had been broken in two and joined together again with an appreciable bend. Even though this was the case it now differs only from a true yard by 0·01 in. and can be seen in the Science Museum, London. It was the basis for measurements of length for Thomas Newcomen, James Watt, and other famous engineers of the past.

Watt's micrometer (constructed about 1772), which was graduated according to the length of this yard and is illustrated in Fig. 11, was constructed to read to 1/1,800 in. Later Joseph Whitworth made (1834) a measuring machine which, to an accuracy of one-millionth of an inch, could measure the difference in length between two yard-standards. But, the Royal Society of London required, for scientific purposes, a better yard-measure than Queen Elizabeth's so they commissioned (1742) George Graham to produce one; the result is shown in Fig. 12.

ACCURACY FOR INDUSTRY

Attempts were made in France, about 1778, to increase the accuracy of production to such an extent that interchangeable parts could be made for firearms; such parts would be cheaper to make and maintain. These efforts were unsuccessful, however, but Eli Whitney, in America, employed improved machines, templates, gauges, and jigs, and reached better results for firearms about 20 years later. Interchangeability of parts for industrial machinery was not possible until near the end of the Nineteenth Century when engineers could manufacture more accurate precision tools. The rapid development of technology that began in the Eighteenth Century called more strongly every year for greater accuracy in production, and more efficient tools were gradually evolved.

A Royal Commission prescribed a new yard-measure with a dot cut into a gold stud at each end between 1758 and 1760. The distance between the dots was a yard. This measure was made a legal standard in 1824 and for safety was placed in the House of Commons. Unfortunately it was there destroyed by fire in 1834.

The current imperial yard was constructed in 1845 as a result of many investigations. Studies were made with a view to finding the best metal-alloy for this purpose, the correct shape, and the effects of temperature variations upon its accuracy. Copies of the standard are now kept at the Royal Mint, the Royal Society, the Royal Observatory, the Houses of Parliament, and also at the Standards Department of the Board of Trade.

Fig. 13 shows Baily's line-yard of 1844, which served as a prototype for this standard. A small gold stud with finely engraved lines was inset on the bottom of a well-hole at each end. The correct length of a yard was obtained by viewing, through a microscope, the central lines on the studs and noting the distance between them. This had to be done when the temperature

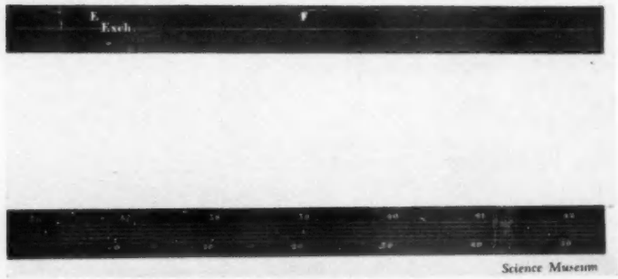


Fig. 12 Top: one end of the Royal Society's standard yard (1742). Bottom: one end of General Roy's 42 in. standard scale (*circa* 1784).

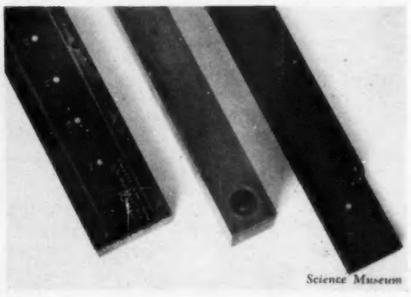


Fig. 13 Left to right: Kater's 36 in. scale (1830 to 1831); Baily's line-yard (1844); and Kater's Imperial line standard yard (1842). These standards made use of small gold studs carrying finely engraved lines.

was 62 deg. F. and the barometric pressure was 30 in. of mercury.

Modern production and the attainment of automation would certainly never have been possible without the careful attention that was paid to our basic measures by early technologists. This was essential for obtaining the requisite tolerances to which all interchangeable parts on modern machines are made. In some respects the growth of technology—and science—has followed man's ability to measure linear distances with increasing accuracy—from the Tower of Babel, built with a simple cubit measure, to the present day, when interchangeable machine-parts are made on precision machines and measured with gauges to an accuracy about three hundred times as great.

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Further information on this subject may be found in the following:

Chambers's Encyclopædia (1954), under "Measures."
Historical Metrology, by A. E. Berriman, 1953.
The Story of Standards, by John Perry, 1955.
Measures and Weights, by Sir W. M. F. Petrie, 1934.

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Letters to the Editor

SCIENTIFIC RESEARCH IN BRITISH UNIVERSITIES

SIR, I have noted that in the mention of *Scientific Research in British Universities* in "On the Shelf" in your issue of September 20, 1957, it is stated that this work is compiled by the Department of Scientific and Industrial Research. However, reference to the introduction to the work will show that, in fact, "the material has been collected as in previous years by the British Council." The Department of Scientific and Industrial Research is concerned with the sponsorship of the publication and not with the compilation of the material.

Yours faithfully,

E. BOLTON KING,
Assistant Controller,
Arts and Science Division (Science Group).
The British Council,
65 Davies-street,
London, W.1.
September 24, 1957.

★ ★ ★

MANAGEMENT AND BAD WRITING

SIR, May I offer a final piece of frivolity on the subject of "Management and Bad Writing"? It goes to the tune of Mikado's song.

You prosy dull short-Saxon-word-addicts
Should treat your words like flowers—
So don't be a chap
Like Reginald Kapp
Or even Sir Ernest Gowers.
For elegant padding, in moderation,
Your efforts will improve
And words in the common (or vulgar) tongue
You'll carefully remove.

CHORUS

My object all sublime
I shall achieve in time,
To write my notices all in rhyme,
My notices all in rhyme:
My foremen I shall please
With classical Mitfordese
All naughty words will be a crime
Short, naughty words a crime.

Your faithfully,

A. BATTERSBY.

8 Cranbourne-drive,
Pinner,
Middlexex.
September 26, 1957.

Automobile Engineering

CARS FROM JAPAN

Japan produced 113,000 vehicles in 1956. It is understandable if motor manufacturers in this country were comparatively unperturbed by this news, for the number is certainly small compared with the United Kingdom production of a million units in that year. But against its statistical background, the figure is more ominous, for it is 60 per cent. above the 1955 level, and the Japanese car industry was only freed from Occupation controls in 1954. Japanese manufacturers are now talking in terms of a further 30 per cent. increase in 1957. Hitherto the Japanese motor industry has been mainly concerned with consolidating its position in the home market and living down its reputation for poor quality. There are now signs of a large-scale move into the export field with cars that compare well on quality with western models.

In July, 1957, the Tyota Jidosha Kogyo Company announced an impending tour by one of its directors to the United States, Venezuela and Cuba. This company, in common with other Japanese producers, is fully aware of the success of the small car-manufacturer in the American market, and is also alive to the fact that with excess capacity in the Japanese motor industry, the best way of keeping average costs and prices down is to sell more abroad. Initially, Tyota aim to sell on the United States market a small 4-seater car with a top speed of 60 m.p.h. and a high gear ratio, at a price somewhere in the region of £400. This will be followed by the Tyopet Crown sedan, which is about the size of the Austin Cambridge, and sells in Japan for £1,100. Details of a sales organisation based on Los Angeles are at present being worked out. Another Japanese concern, the Nissan Automobile Company, will also shortly invade the American market. Nissan, which mainly manufactures buses and trucks, also produces a small passenger car, the Datsun, selling in Japan for about £750.

While the American market promises good outlets, the Japanese motor industry is also well placed for markets in the Eastern hemisphere. The recent Australian/Japanese trade agreement, providing tariff concessions, is likely to prove profitable for Japanese motor manufacturers. Tyota hopes to sell a large number of jeep-type (a traditional Japanese vehicle) vehicles at a price of around £200. Meanwhile, the Japanese have been busy across the China Sea. In 1956, exports of cheap three-wheel trucks to China accounted for virtually half the total exports of 1,700 vehicles of this type. (In 1955, only 151 of these models were sent abroad.)

Japan has a highly developed Diesel engine industry, which should help in the growth of commercial vehicle manufacture. About 300 Mitsubishi-Fuso buses have been sold to Chile in the last two years, and Mexico plans to buy 57 Nissan buses. The rays of the Japanese sun are now casting an uncomfortable gleam nearer home. Fiji Precision Instruments aim to show their Prince Skyline, a smart looking large saloon costing £1,100, at the Paris show.

HUMANISING THE TRAFFIC SIGNAL

There is a growing tendency to talk of "electronic brains" without examining the qualities which make the description appropriate. Ingenious as the modern road traffic signal undoubtedly is, its occasional habit of beckoning with a green and then changing back to red before a driver at the rear of a waiting queue has time to reach it, appears to many motorists to be deficient in understanding to say the least. An improvement in this respect was seen in a new controller shown at the recent Torquay conference of the Association of Public Lighting Engineers, by the Siemens and General Electric Railway Signal Company, Limited. This device will count and remember the number of vehicles approaching a red signal, and use this information to adjust the green period appropriately when the right-of-way is given. The previous practice of a minimum green period, which may be inadequate by day and excessive by night, is a possible encouragement of disobedience to signals. Another facility will delay the warning that a signal is about to change to green, until drivers hastening over the crossing during amber for the other road have had time to get out of the way of those who interpret amber-with-red as an invitation to start rather than a warning to stand by. These several features, represent an interesting trend on the part of the modern "electronic brain" to take account of human feelings and foibles. The psychology of the pedestrian also, has been studied, and some pedestrian-operated signals are being equipped with "wait" signs which light up when he presses the button, to reassure him that the automaton has noted his request although there is some hard thinking to do before it can safely be granted.

Obituary

MR. L. H. HOUNSFIELD

Mechanical engineers and physicists will have learned with regret of the death of Mr. Leslie Haywood Hounsfield which occurred on September 17. Mr. Hounsfield, whose name will always be linked with his tensometer tensile-testing equipment, was born in 1877 and received his education at Brighton Grammar School. He was apprenticed to James Simpson and Sons, Limited, Grosvenor-road, Pimlico, London, later Worthington-Simpson Limited, and continued his studies at the Battersea Polytechnic. In 1898 he obtained a Whitworth Exhibition and entered the Royal College of Science, London, as a Royal Exhibitioner. Mr. Hounsfield's scientific career, however, was interrupted by service in the South African War of 1899-1902 but, on his return, he obtained the associateship of the College (A.R.C.Sc.) in mechanics, in 1902. After serving as an assistant to Colonel Crompton in his laboratory, Mr. Hounsfield joined the firm of Ransomes, Sims and Jefferies Limited for a time and also worked at Woolwich Arsenal.

Although Mr. Hounsfield's name is connected with mechanical testing machines, in which branch of science he had spent much of his later life, he was also engaged on internal-combustion engine research for many years. He had a good deal to do with the early development of the Trojan motor-car and became managing director of Trojan Limited, Croydon, a firm established in 1914. Subsequently Mr. Hounsfield became chief engineer of the Kingston-on-Thames Works of Leyland Motors Limited. Altogether, Mr. Hounsfield was responsible for 15 patents in connection with motor-cars.

The firm of Tensometer Limited, Croydon, of which Mr. Hounsfield was managing director, was registered in July, 1930, for the production of testing machines and equipment. He was also managing director of Hounsfield Limited.

Mr. Hounsfield was awarded a tribute by the Automobile Division of the Institution of Mechanical Engineers for 40 years of continuous service on the A.D. Council. He was made President of the Institution of Automobile Engineers for the session 1928-1929 and was President of the Whitworth Society in 1944. He was elected an associate member of the Institution of Mechanical Engineers in 1907 and made a member in 1914. He became an associate member of the Institution of Civil Engineers in 1904.

Companies in the News

New Horizons

The Suez Canal Company has plans to start afresh and become a considerable power in the industry of western Europe in the next decade. Their French chairman, M. Georges-Picot, informed a recent meeting of holders of founders' shares that claims for indemnity for the nationalisation of their assets in Egypt would be submitted to arbitration. Prior negotiations were being conducted through the United Nations.

The company's reorganisation aims at "furthering activities of an international character tending to develop commercial links between nations." With this in view they purchased a 30 per cent. share in the Channel Tunnel study project and have invested a substantial sum in oil prospecting in the Sahara which is to begin next year. They are also planning to support development of the Mauretanian and Gabon iron mines in West Africa. In all these cases the services or commodities concerned have an essentially international flavour and could serve well as a basis for expansion in the same fields. The establishment of a European road and rail network, of which the Channel Tunnel would be a vital part, is likely to become one of the chief necessities of the next few years as the economic integration of the area proceeds. Oil and iron ore are major needs of the European countries envisaged as the European Free Trade Area. To secure rights and develop supplies would constitute a lively European activity, well in line with the Suez Canal Company's new objectives.

The meeting called to discuss these things was unable to transact its business as the quorum of 50 per cent. of the 100,000 founders' shares was not present. Another meeting, at which the required quorum will be a third, is to be called for October 15.

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Britannia Delays

Bristol's Britannia airliner has recently been the subject of much unfortunate and misguided publicity. Disappointed, perhaps, by late deliveries, and by the continued recurrence of engine icing troubles necessitating many unscheduled engine changes, certain B.O.A.C. officials have made statements which, translated by the daily Press, have over-emphasised the magnitude of the teething troubles and conveyed the impression that B.O.A.C. were unhappy with their choice. In fact, the Corporation are keen to add to their Britannia fleet, and are hoping to take over the five Britannia 305 airliners which Northeast Airlines of America have declined to receive until next year.

Although there is no doubt that the recent fuss about the Britannia has created an adverse atmosphere in the United States, it seems unlikely that it influenced Northeast Airlines in their decision to delay reception of the aircraft. This decision has arisen because the five planes concerned were intended for a highly seasonal winter-holiday route starting early in December —and they are some eight weeks late in the production schedule, which means simply that they would not be ready in time for their appointed task. In this case, the Bristol Aeroplane Company, Limited, cannot be wholly blamed for the delays—and certainly the sub-contracting firm who are actually constructing the 305 Britannias, Short Brothers and Harland Limited, are in no way responsible. The difficulties have arisen because the American certificating organisation, the Civil Aviation Authority, will not accept the Air Registration Board's requirements and have demanded 114 modifications, many of which Bristol were not asked for until January this year, and some of which have involved major changes, such as modifying the undercarriage forgings to withstand ground-manoeuvring conditions which, in British thinking, are purely fictitious. Other serious modifications included changing the shape of the emergency exits and modifying the fire-extinguishing system.

Although the chairman of the Bristol Aeroplane Company was at pains to emphasise that Bristol had no quarrel with the C.A.A., and that recently the Air Registration Board had succeeded in improving the licensing arrangements with C.A.A. in June this year. A.R.B.'s chairman, Lord Brabazon of Tara, speaking before the Society of Licensed Aircraft Engineers, said: "We in this country refuse to accept a situation where we do everything to make validation of American machines easy, while the C.A.B. and the C.A.A. concentrate on making them more difficult for the validation of British machines in America."

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Competition in Export Markets

A useful compilation of export information for companies interested in markets overseas has been made by the British Engineers' Association in a special supplement. The statement compares the performance of the British engineering industry in export markets, from 1952 to 1955, with foreign countries.

Taking exports as a whole, the figures show the outstanding position of the United States the United Kingdom and Western Germany in world engineering markets. Exports of machinery and electrical apparatus from the United States in 1956 were £1,366 million, an increase of 36 per cent. on 1954. United Kingdom exports at £721 million increased over the two years by nearly 25 per cent. and those from Western Germany at £711 million by 40 per cent.

Among the tables analysing exports of machinery and electrical equipment by countries there are a number of interesting features. Exports of engineering products to the United States, for example, show that Canada has lost some ground while most progress has been made by the United Kingdom and Germany. Imports into Germany show the major sources to be the United States and Switzerland but there are signs of imports from the United Kingdom (which rank third) increasing their rate of import in 1956. Italy also takes most of its imported engineering equipment from America and Germany, with Britain a poor third. In Scandinavia, Britain has lost ground seriously to Germany in both Norway and Sweden.

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Pumps

The progress of Pulsometer Engineering appears to be quite unconnected with any of the financial deals that have taken place over the past year or so. Eighty years of pump manufacture have given them deep roots in a business where tradition exerts a strong influence on buying practice. Despite their own very traditional approach Pulsometer have contrived to take part in most technical advances in their field. They are leaders in process pumps, through their manufacturing licence arrangement with the United States company Pacific Pumps Inc. The Pulsometer-Pacific oil refinery process pump is both popular and highly competitive. The company's recent purchase of the Self-Priming Pump and Engineering Company last July further broadens their trading basis, which includes the atomic energy field. S.P.P.E. introduce in the group a range of fuel pumps and hydraulic equipment which will greatly strengthen their position as suppliers to the aircraft industry.

Other companies in the industry have been very active, particularly the other two large companies, the G. and J. Weir group (which includes Drysdale) and Worthington-Simpson. The former announce the resignation of an old servant, Mr. John Young, from the Board, though he will continue to be available in an honorary and consultative capacity. Weir are likely to find their resources fully taken up for several years due to the unprecedented boom in shipbuilding and may well improve further their already very strong competitive position.

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Oil Engines

Three leading makers of oil engines, Associated British Engineering, W. H. Dorman and William Doxford, reported satisfactory progress and a promising, though highly competitive, outlook. Of the three, A.B.E. are the only company to make an automotive engine, through their subsidiary Henry Meadows of Wolverhampton. Significantly perhaps it was that company which experienced the only serious difficulties the group met during the year. Although these were connected with a suspended order for Egypt (generating plant) and the inability of India to keep up imports, there is a tendency towards self-sufficiency on the part of the Diesel-engine users in the motor-vehicle industry which has troubled even firms with considerable volume of output, such as F. Perkins. Rootes, Ford, B.M.C., and now Vauxhall make their own light oil engines and so do most of the heavy commercial vehicle builders. All these companies also exploit the marine and industrial markets.

Automotive engines apart, demand for proprietary Diesel engines has been very good and prospects are encouraging, particularly in the marine field. A.B.E.'s chairman, Mr. Lawrence W. Robson, stated that he has "every confidence" that the group's marine-engine division "will maintain their present level of earnings." Doxford increased their dividend from 20 to 22½ per cent. and the engine division is known to be making rapid and highly satisfactory progress.

Dorman's chairman, Mr. Darby Hadden, was, however, very concerned with rising costs and their impact on overseas sales. Despite substantial expansion during the past year, and the extension of their range to 800 h.p., Dorman cannot overlook the possibility of being forced out of their best markets. For them, as for some of A.B.E.'s companies, any doubts that exist centre on the ability to compete—the trend of demand for oil engines is still sharply upwards.

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Uncertain Future

The report of the directors of Winget Limited, makers and hirers of contractors' plant, was written before the Chancellor's announcement of a new and more severe round of credit restrictions. Even then, on September 9, the directors considered that "the future will inevitably be affected by the uncertainties and restrictions arising from the changing economic and political scene not only at home but in our overseas markets." It seems likely that during the next 12 to 18 months there will be a sharp drop in the demand for housing and building of all kinds, and that this will affect makers of concrete machinery and contractors' plant.

An interesting aspect of Winget's expansion has been their entry into the hiring field and their purchase of some of their selling agents. Moore's Plant Limited, who have for many years acted as distributors of Winget products in the greater London area, have been taken over, on the belief that "the closer co-operation and collaboration thus made possible" will benefit both the company and their customers. Prior to this they had completed the acquisition of Plant Engineering Services (Exeter) who, like Moore, sell and service contractors' plant. Whether Winget's entry into the hiring business was the mere consequence of taking over Moores, or a deliberate policy is uncertain.

Winget's formation of a separate company to handle the refrigeration side of their business marks the beginning of a policy of diversification, which few manufacturers of contractors' plant can afford to neglect.

Materials

CREEP AND CREEP TESTING

The term creep, as applied to the continued extension of a metal test piece when loaded at elevated temperatures, is now well understood by engineering designers and very many hundreds of tests for the study of the creep behaviour of steels and other alloys have been made, or are under way, in numerous industrial and research laboratories in this country and throughout the world. In view of the widespread interest in the subject, it may come as a surprise to some that the study of the creep of metals, now carried out under well established conditions, is of comparatively recent introduction. The first work was done on steels, and among the first, if not the first, to conduct a series of experiments was the late Mr. J. H. S. Dickenson, head of the research laboratories of Vickers Limited, Sheffield. In the detailed account of his investigation, given before the Iron and Steel Institute during an annual autumn meeting, held in York in September, 1922, Mr. Dickenson described the "flow" which took place in carbon, nickel-chromium, stainless, and high-speed steels when they were subjected to stress at a low red heat. The, perhaps more appropriate, word "creep" was substituted for "flow" at a subsequent date, but Mr. Dickenson's apparatus, although somewhat crude and elementary in appearance and construction when viewed after an interval of 35 years, was indeed creep-testing apparatus, just as his curves were, in effect, true curves of creep behaviour.

It is, moreover, of interest to note that, in his reply to the discussion on his paper, Mr. Dickenson found it necessary to repeat and re-emphasise his statement that such claims, which he said had been made in more or less official reports, that "a high-speed steel had a tensile strength of 20·1 tons per sq. in. at 650 deg. C." were not only meaningless but might be misleading. He pointed out that the test referred to was of short duration with an actual loading time of a few minutes only and that the steel would stretch continuously, and finally break, under a much lower load, if given time.

With the passage of the years creep-testing apparatus has been perfected and the work is now almost of a routine nature. What is still exercising the minds of metallurgists, however, is to furnish an exact explanation of what happens to the structure of a material during a creep test and to give an accurate description of the causes and nature of crack inception and propagation and final failure.

While it would be wrong to state that a discussion on the theme of "creep," held during the autumn meeting of the Institute of Metals in Glasgow on September 17, was largely of a theoretical nature, the fact remains that the papers presented and the discussion which took place on them were of greater interest to academic than to practical metallurgists. The obvious retort to this, of course, is that a designer who is familiar with modern concepts of the theoretical side of creep phenomena will be all the more efficient for having absorbed such knowledge.

In all, five papers were considered at the meeting, two of them dealing mainly with questions related to grain-boundary sliding and the other three with various forms of fracture brought about as a result of creep.

The two papers on the effect of grain-boundary sliding consisted of communications from the National Physical Laboratory by Dr. D. McLean and Mr. M. H. Farmer, and from the Massachusetts Institute of Technology, by Mr. H. Brunner and Professor N. J. Grant. McLean and Farmer carried out their creep tests on copper, iron, cadmium, zinc, tin, the R.R.58 aluminium alloy, a copper-0·37 per cent. beryllium alloy, and super-purity aluminium. As a result of their findings they outlined a suggested new mechanism for grain-boundary sliding. Brunner and Grant in the course of their work derived an equation which relates shear displacements and elongation in a tensile specimen. They added that this equation permits the calculation of the elongation of a tensile specimen caused by sliding along any particular grain boundary.

The three papers on cracking and rupture as a result of creep will perhaps be of more immediate interest to engineers than the two contributions just mentioned. As a result of their investigation on the influence of various stages of heat-treatment on the structure and the creep properties, at 750 deg. C., of the nickel-chromium alloy hardened with titanium and aluminium, known as Nimonic 80A, Dr. W. Betteridge and Mr. A. W. Franklin, of the Mond Nickel Company, Limited, have found that three factors control the creep characteristics of the material. In the first place the time and the temperature of the solution treatment of the alloy largely determine the creep rate. The complete solution of the essential phases is effected only at temperatures above about 1,150 deg. C., and solution treatments of this complete type lead to low creep rates. Secondly, the manner of precipitation of chromium carbide has an important influence on the amount of creep extension which occurs before fracture, and by maintaining the alloy for some time at a temperature in the region of 1,000 to 1,050 deg. C., a favourable distribution of carbide at the grain boundaries is obtained. Finally, the time and temperature of precipitation of the normal hardening phase Ni_3 (Ti, Al) affects, to a lesser degree, both the creep rate and the extension at fracture. A two-stage treatment normally employed provides a reasonable compromise in properties giving a low creep rate and a long life with increased creep extension before fracture.

In the second paper on creep and rupture, a communication from the National Physical Laboratory on the metallography of cracking during creep, Dr. D. McLean stated that practical experience with creep-resisting alloys has shown that some impurities are harmful. He added that the occurrence of many more cracks than usual in bands of presumably irregular composition in alloy G32 (the percentage composition of which is given as: Co 48, Cr 20, Fe 13, Ni 11, V 2·5, Mo 2·3, Nb 1·3, Mn 0·8, Si 0·4, and C 0·3), and alloy Rex 337A (C 0·18, Si 0·6, Mn 0·6, Ni 18, Cr 14, Cu 4, Ti 0·8, Mo 4, Co 7, and Fe, the balance) presents probably an example of impurities making it easier for cracks to form. Dr. McLean concluded that it may be that if the content of certain impurities could be reduced still further, these materials would fracture less easily. He did not offer, however, any clue as to the nature and quantities of these "certain impurities" but, quite possibly at this stage of the investigation, he does not care to commit himself but is awaiting confirmation provided by further research.

The third paper on cracking and creep was of a distinctly academic nature. It was by Mr. B. J. Nield and Professor A. G. Quarrell and described a systematic study, carried out in the University of Sheffield, of the occurrence of intercrystalline cracking during creep of two high-purity-base aluminium alloys containing 1·28 per cent. of manganese and 5·15 per cent. of magnesium, respectively.

Their work has prompted the authors to propose that there are two main processes operating in the mechanism of crack formation during creep. These are "relaxation" at grain boundaries, which permits boundary sliding; and grain-boundary migration. The relationship between these two processes in any one material, the authors believe, dictates fracture behaviour.

If there is one general conclusion that has emerged from this latest discussion on creep at Glasgow, it is that no cutting down of the time taken over the testing of specimens in creep is possible and that the long-time tests, usually lasting many months, must continue as heretofore. Another matter of interest touched upon was that impurities in a material as low as, say, 10 parts per million, had a distinct significance when viewed from an atomic point of view.

THE WEAR OF METALS

When delivering the twenty-eighth Autumn Lecture of the Institute of Metals, on September 17, in Glasgow, Dr. F. T. Barwell, Head of the Lubrication and Wear Division in the Mechanical Engineering Research Laboratory of the Department of Scientific and Industrial Research, at Thorntonhall, Glasgow, spoke on the subject of the wear of metals.

In the course of his lecture he stated that wear was a familar term but one which was somewhat difficult to define. After some discussion, a committee of the Institution of Mechanical Engineers had adopted the following definition—"The progressive loss of substance from the surface of a body brought about by mechanical action (usually it reduces the serviceability of a body but can be beneficial in its initial stages in running-in)."

In engine cylinders, lubricants which not only prevented the aggregation of carbon-containing abrasive material but also provided alkalinity to neutralise the acids arising from combustion or lubricant deterioration, had shown remarkable effectiveness in the reduction of wear. However, less was known of the required properties of the rubbing surfaces or of the detailed design in order to reduce wear. Work at the Imperial College and at Cambridge had shown that, in favourable circumstances, piston rings could operate hydrodynamically. There was no reason to believe that the piston itself might not operate similarly. The engineer therefore has some responsibility to produce thick lubricant films in order to reduce the abrasive nature of cylinder wear but the corrosive element must still make demands on the metallurgist.

Again, in the bearings of engines, these should normally operate hydrodynamically although, because the load varied in a very complicated manner, both in magnitude and direction, hydrodynamic conditions might break down locally. Moreover, conditions at starting were probably not hydrodynamic. Therefore local wear might be expected, although a conformable material might soon assume a form conducive to the maximum exploitation of hydrodynamic lubrication. In most cases, however, the same lubricating oil was used for the bearings as for the pistons and this might contain corrosive agents. The environmental factor, therefore, became of considerable importance. This was overcome technically by the addition of appropriate additives to the lubricating oil. Metallurgical aspects of the bearing materials, however, were of considerable importance. In particular, on account of the pulsating nature of the load, the parent metal was subject to fatigue. To some extent in the case of white metals, this might be overcome by restricting the thickness and providing a steel backing, but in more rigorous situations it was usual to resort to the use of leaded bronzes which did bring more corrosion problems.

A particularly onerous form of gear was the "hypoid" rear axle, on account of the particular sliding conditions arising from the offset of the axle relative to the shaft. Such gears would not operate when lubricated by conventional mineral oils and their extensive use in automobile engineering had been rendered possible solely by the invention of extreme pressure additives.

Continuing **Metals and Materials**

EXPANDING USES OF ARTIFICIAL TEXTILES

Over the past 50 years the world consumption of textile materials has roughly trebled, and although during that period the growth of the infant man-made fibres has been phenomenal, some 75 per cent. of this textile consumption has been derived from natural sources—wool, cotton, silk and flax. The world population is still increasing, and because food-growing will become increasingly important, it follows that textiles will have to be produced more and more from synthetic or wood-pulp fibres that do not demand large areas of agricultural land for their cultivation.

Foreseeing, therefore, that the man-made fibre industry can have important effects on the national economy, Courtaulds Limited—the firm that pioneered the development of viscose rayons just over 50 years ago—are expanding their activities. They have recently brought into production a new viscose-staple plant at Grimsby, and they will soon be going into medium-scale production in Coventry with acrylic fibre (hitherto only on a pilot-production basis). In about two years' time, another large-scale acrylic plant will be opened in Grimsby.

At Rochdale, they have recently opened a new textile development unit, adjacent to their Arrow Mill which concentrates on spinning (and other methods of converting) man-made fibres into yarn and fabrics. The new textile development unit, which has a floor area of 54,000 sq. ft. in the development shed alone, excluding offices, laboratories and stores, houses an impressive assembly of textile machinery of British and overseas manufacture, including some of the latest equipment, such as that used for the manufacture of tufted carpets, still under development; but also including a substantial proportion of the older machines that are still giving excellent service in the mills of Lancashire and Yorkshire. The primary purpose of the textile development unit is to develop the best methods for spinning, processing, weaving, knitting and carpet-tufting man-made staple fibres, so that when they are introduced to the textile manufacturing industry, the spinning and weaving processes can go smoothly ahead without involving the textile manufacturers in difficult teething troubles.

Fires are burning fiercely within both these sheds. The one on the left, however, has been treated with Dohmseal fire retardant inside and out.

RETARDING THE SPREAD OF FIRE

An effective demonstration of the fire-retarding properties of Dohmseal, a liquid ceramic coating for building materials made by Dohm Limited, 167 Victoria-street, London, S.W.1, was given in London recently, when fires were set alight inside two small wooden sheds, one of which had been painted with a Dohmseal coating inside and out, the other being untreated. The latter caught fire almost at once and was reduced to a skeleton within 2½ minutes. The treated shed withstood the fire for some 7 minutes before flame began to penetrate through the joints of the wooden members, and it did not catch fire as a whole until 15½ minutes after the fire had been started.

The Dohmseal coating, applied by brush or by spraygun on to a clean oil-free and paint-free surface, dries to form a rock-like silica coating, which isolates the flames from the wooden structure and allows time for a carbon deposit to form behind the sealing medium.

For maximum protection, all surfaces of each member, including the ends and sides of the material, should be coated—a condition which was not realised in the test described above, since the shed had been treated after erection. The coating is suitable for treating cork, hardboard, acoustic tiles, etc., as well as timber. It is also claimed by the makers that the coating has been widely adopted recently by the National Coal Board and other mining authorities for treating wooden pit props and supporting beams.

ELECTRICAL WIRING FOR AIRCRAFT

Four new types of electrical wiring have been introduced recently by British Insulated Callender's Cables Limited. Nyvin cable uses fire-resistant P.V.C. insulation over which is applied a glass-fibre braid and a nylon sheath or lacquered nylon braid; it is claimed that it keeps dimensions and weights to a minimum while ensuring excellent overall performance as a general-purpose cable. The insulating materials will not propagate flame, and they resist deformation at elevated temperatures yet are flexible down to — 30 deg. C. The outer covering of nylon is highly resistant to abrasion and provides protection from hydraulic fluids and all fuels and engine oils including ester-base lubricants.

Tersil cable is a greatly improved silicone-rubber insulated cable of lightweight construction. It is suitable for use over a working range of temperatures between — 55 deg. C. and 190 deg. C., and its ability to function after exposure to a 1,100 deg. C. flame for five minutes makes it particularly suited for use in vital circuits. Should the silicone rubber insulation be burnt during a fire it will still retain good insulating properties and will be retained in position by the cable's protective glass braid. This specially-developed protective covering of glass and Terylene braids gives good handling properties and resistance to attack by chemicals, heat and abrasion.

Uni-Efglas cable has been designed for operation in high ambient temperatures and is rated for maximum continuous operation at + 240 deg. C. The cable is insulated with a P.T.F.E. and glass insulation which is completely unaffected by all aircraft oils and fuels, and has a high abrasion resistance. The insulating medium remains flexible down to — 75 deg. C.

A new P.T.F.E. insulated wire has been developed to meet the increasing demand for an equipment wire able to operate at high temperatures. This wire has its insulation applied as a lapped tape, giving it a tough and highly flexible construction. This makes it eminently suitable for the internal wiring of airborne electronic equipment. The new wire is rated for continuous operation at temperatures as high as + 250 deg. C.

FIBRE METALLURGY

To the four familiar ways of shaping metal—casting, forging, machining and the moulding of powders—is being added a fifth, the sintering of fibres. It has been known for some time that many problems could be solved if suitable metal fibres became available.

The manufacture of metal fibres presents considerable difficulties, particularly from metals possessing the requisite hardness and heat-resistant properties. The American Viscose Corporation are said to be in the final stages of developing an inexpensive new method of spinning metals, which has been likened to the way "cotton candy" (or candy floss) is made at fun fairs. This should make it possible to utilise the knowledge gained at the Armour Research Foundation, Illinois Institute of Technology, in the sintering of metal fibres. In addition to turbine blades, filters, aerofoils in de-icing systems, a wide range of cooling systems, storage batteries are all possible applications where the new process could be used. Looking further ahead fibre metallurgy may enable aircraft manufacturers to push back the heat barrier considerably beyond Mach 2. The shapes can be made porous or non-porous as desired, and if the entire wings of aircraft could be porous and yet strong, the system of reducing air turbulence over a wing, by sucking a steady flow of air through the skin from inside the wing, could be perfected, making possible a better distribution of air flow, giving the aircraft increased lift with less drag. There are many other applications, including reinforcement (for example a supporting skeleton) for plastic materials.

Seven American companies, including Westinghouse Electrical, have acquired licences to use Armour's basic fibre metallurgy patents. The success of American Viscose in producing the fibres will considerably advance their work. American Viscose started on this development some 5 years ago and called in Arthur D. Little, Incorporated—the development engineering consultants—to explore some of their ideas and subsequently purchased the exploiting rights of patents in the same field. They now expect to produce smooth continuous fibres, at a cost only a few cents above the ingot price for the basic metal.

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The launcher for the Bristol-Ferranti Bloodhound guided missile is made by Chatwood Milner Limited to Bristol design and not, as stated on page 350 of our September 13 issue, by the M.L. Aviation Company, Limited. The latter company were responsible for the design and construction of the Bloodhound loading trolley.

Plant and Equipment

BUTT WELDING STEEL PIPES

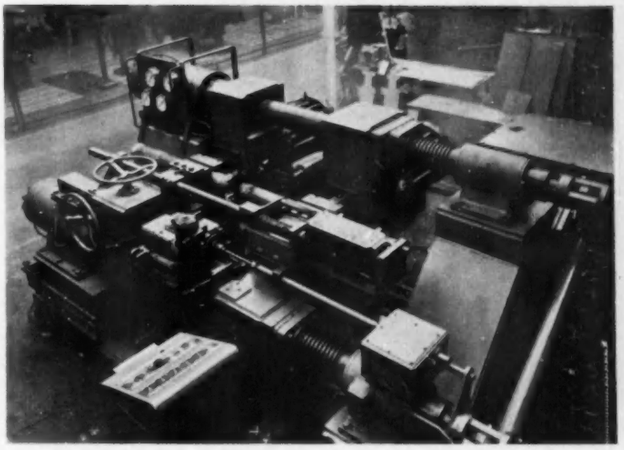
A process developed by the British Admiralty for high-quality butt welding of steel pipes is the basis of a new welding machine introduced by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17. The machine is designed for butt welding low-carbon and low-alloy steel pipes in sizes ranging from 3 in. bore by $\frac{3}{16}$ in. wall thickness to $6\frac{1}{2}$ in. bore by $\frac{1}{2}$ in. wall thickness. Designs can be prepared for dealing with other tube sizes. Joints can be made between pipe and pipe or between pipe and pipe flange, by using a suitable adaptor plate. The weld has a smooth compact upset section which, for most applications, it is unnecessary to remove. Test requirements for high-pressure pipelines can be met easily. Heat treatment is necessary after welding, normalising being sufficient for low-carbon steel pipes, while normalising and tempering are required for low-alloy steels where air-hardening tendencies are present. Straight normalising is also possible.

In its essentials the process consists of a three-part sequence. The prepared faces of the pipes to be joined are brought together under a light load and heated by means of a multi-jet oxy-acetylene oscillating ring burner until a pre-set thermal expansion is reached. A second higher, or control, load is then applied to return the pipe to its original length, and finally the upset load operates to complete the weld. Sequence control is fully automatic and the gas is cut off just before the completion of the weld.

There are two work clamps, both of the direct-acting hydraulic type, and the maximum clamping load is 100 tons. The right-hand clamp assembly is attached to the main tension bars by split collars, which allow the distance between the clamps to be varied from 12 to 26 in. to accommodate tube fittings. Horizontal and vertical adjustment are provided on the left-hand clamp for tube-end alignment.

Movement of the tension bars is controlled by twin hydraulic cylinders, which can exert a final upset load on the weld of 50 tons. A self-contained hydraulic system supplies both the clamping and the upset cylinders, and there is independent adjustment for each of the three-stage pressure cycle stages. The water-cooled burner ring is mounted on a roller carriage, by which the ring can be adjusted so that it is concentric with the weld. The motor for oscillating the burner ring is mounted on the carriage.

Control of the machine is from an operator's desk, which has all the necessary electrical controls for normal operation, and also for preliminary tests when clamping from one size of pipe to another. The desk also houses the special gas-control and mixing unit and the gas-flow indicators. Service requirements are: standard 380/440-volt 3-phase alternating current for the 10 h.p. pump motor and control gear; clean, water at 1 gallon per minute for cooling; and an adequate supply of oxygen and acetylene gas.



Steel tubes are butt welded to meet the highest test requirements in a three-stage automatic sequence in this Metropolitan-Vickers machine.

MOBILE HYDRAULIC JAWS FOR MATERIALS HANDLING

A new version of the well-known " Brayloader," made by W. E. Bray and Company, Limited, Faggs-road, Feltham, Middlesex, is now available. Known as the " Hydraclamp," the loader consists of a pair of hydraulically-operated jaws, built of steel tines, mounted on the main boom of the vehicle. Three double-acting hydraulic jacks are directly connected to the clamp and enable the jaws to be opened and closed, and the whole unit to be pivoted at the end of the boom. Normal Brayloader hydraulics control the boom itself, which can be raised and lowered as required. The complete assembly forms a large mechanical claw, which can be manoeuvred as required to lift, transport and deposit a great variety of loads.

A typical use for the machine is illustrated below. It is driven up to a pile of pit props, with the bottom row of tines on the ground, and the top row lifted to clear the props. As the vehicle travels forward, two hydraulic jacks apply pressure to the lower jaw to keep the tines in contact with the ground, and the tapered ends of the tines pass under the props. When the lower jaw is filled, the forward movement of the vehicle is stopped by the driver, and the top jaw is lowered, by means of a further hydraulic jack, the tines cleaving down into the pile of props to encircle the load. The vehicle is now backed away, as shown in the illustration, and the boom can be raised hydraulically if the load is to be discharged at some distance above ground level as, for example, into a motor lorry. It is equally easy to discharge the load at ground level, or at any other point within the range of the boom.

Handling articles of relatively long length and small cross-section is, however, only one of the many possible uses for the machine. If it is considered simply as a mobile set of mechanical fingers, which can be opened and closed at will, it is obvious that the loader has almost unlimited applications. It can, for example, pick up and transport large single objects, such as the large stone shown in the second of the accompanying illustrations. A chain attached to the tines enables the loader to be used as a crane, for picking up articles for which hydraulic clamping may not be suitable. The Hydraclamp will, in short, handle almost anything except granular and other bulk loads. If it is required to deal with these, the Hydraclamp can be detached, and the unit converted into a standard Bray shovel.

A load of pit props is picked up by the Bray " Hydraclamp." It can be deposited in various ways, according to need.

Single, large pieces can be handled as easily as large or small numbers of lighter items and more conveniently than by bucket.

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PACKAGED TELEVISION TRANSMITTER

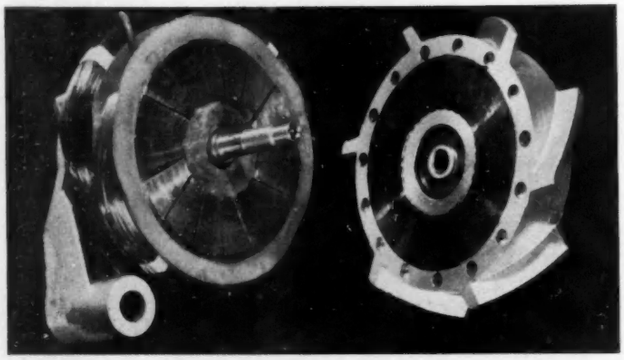
The Independent Television Authority has placed contracts worth approximately £160,000 with Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex, for the transmitting equipment for four new stations. One set of equipment will be installed in the Chillerton Down station in the Isle of Wight and is expected to be working next summer. It is likely that the other three will be installed in stations in north-east England and Northern Ireland.

Each station will be equipped with two 4 kW vision transmitters, two 1 kW sound transmitters, combining units, programme input equipment, and ancillary equipment. The 4 kW vision transmitter, type BD.366, is a Band III unit (170 to 224 Mc/s) designed for world markets. It is capable of handling colour or black-and-white transmissions to either 405, 525, or 625 line standards. The company believe it to be the nearest approach yet to the ideal of a packaged equipment. It is virtually self-contained and designed for installation on any flat floor surface, no sub-floor ducting being required. An alternative version for unattended working is available.

The transmitter is housed in three cabinets that stand side by side to form a continuous front of 7 ft. 6 in., the height being 7 ft. and the depth 3 ft. 9 in. The modulation capability, for monochrome and 405 lines colour, is full picture excursion up to 2·7 Mc/s, while above this frequency the amplitude is inversely proportional to frequency. For 525 and 625 lines colour, full picture excursion is up to 4·5 Mc/s. Amplitude modulation at the grids of the final radio frequency stage is used.

Continuing **Plant and Equipment**

DISC MOTOR



The disc motor dismantled to show slotting of the stator and rotor.

An electric motor in which the rotor can be made part of the driven member is to be made by Limit Engineering Group Limited, Bletchley, Buckinghamshire. The motor operates in the same manner as a conventional induction motor, but the stator and rotor are both disc-shaped. The rotor revolves alongside the stator, and is separated from it only by a small air gap.

As a flange-mounted motor, the disc motor has an overhang length of about one-half that of the equivalent conventional motor and the diameter is increased by about a fifth. The rotor has an inertia about twice that of a conventional rotor. The company say that the cost of manufacture will be competitive with the cost of normal electric motors and maintenance will be simplified.

Unlike a conventional motor in which the magnetic pull on the rotor cancels out, the disc motor does have a resultant pull between rotor and stator. The pull acts along the shaft and is used with advantage in certain designs to give practically instantaneous braking of the rotor. For this purpose the magnetic pull gives a slight axial movement to the rotor so that the rotor engages the braking equipment immediately the stator is de-energised.

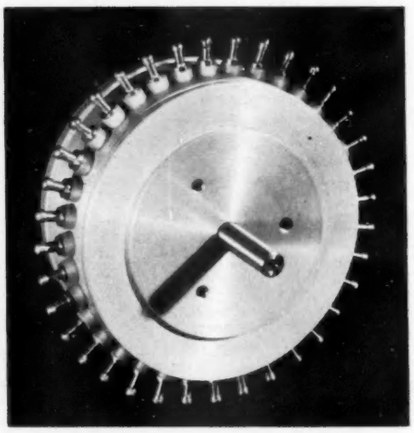
The disc motor, illustrated with the stator and rotor separated, is built around the internal bearing assembly. A light pressed cover is fitted over the motor when it is exposed.

DIESEL-ELECTRIC SHUNTER

The first of three 660 h.p. Diesel-electric shunting locomotives has been delivered to the Steel Company of Wales by Brush Traction Limited, Loughborough. Reference was made to the fleet already in operation at Port Talbot in ENGINEERING of June 28 (vol. 183, page 825). It is claimed that these new locomotives are the most powerful Diesel-electric shunters yet built in this country.

Of the double-bogie four-axle Bo-Bo type, the power is derived from a Mirrlees JS6 turbo-charged, vertical six-cylinder engine which will develop 660 b.h.p. at 875 r.p.m. on the one-hour rating. Bore and stroke are 9¾ in. by 10½ in. respectively. The generator is of the "three-field" type and is flanged-mounted on the engine. The four traction motors are axle-hung and nose suspended, and drive through double-reduction spur gears. With a gross weight of 90 tons a maximum tractive effort of 50,000 lb. can be developed and a continuous effort of 19,750 lb. is achieved at 7 m.p.h. The maximum safe speed for the locomotive is given as 28 m.p.h. Together, the two fuel tanks have a capacity of 550 gallons. Westinghouse straight air brakes are fitted and, as with all the Steel Company's locomotives, two-way radio equipment is installed. The main control switch has three positions—power, engine only, and engine start. A spring automatically returns the switch from engine start to engine only, in which latter position the excitation circuits to the generators are interrupted, allowing the Diesel engine to run free in safety. Moving the switch to the power position closes the excitation circuits of the auxiliary generator, preparatory to starting the locomotive from the master controller. All contactors and relays are of the electro-pneumatic, plunger-operated type.

The lastest Brush Traction Diesel-electric Bo-Bo locomotive to be delivered to the Steel Company of Wales develops 660 h.p.



Multi-tap linear potentiometer showing the terminals for connecting shunt resistors.

MULTI-TAP LINEAR POTENTIOMETER

A precision linear potentiometer, which can, however, be readily adapted to provide a wide range of non-linear functions, has been developed by Salford Electrical Instruments Limited, an associate of the General Electric Company, Limited, Kingsway, London, W.C.2.

This instrument, shown above, is a linear potentiometer with an electrical angle of 340 deg. As will be seen, however, the winding is tapped at intervals of 10 deg., and the connections are taken to turret-type terminals which are arranged round the body. A wide range of non-linear functions can then be produced by connecting shunt resistors across sections of the winding. The potentiometer can be supplied in a range of resistance values from 1,000 to 100,000 ohms.

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FLOATLESS LIQUID-LEVEL CONTROL

A floatless liquid-level control is now being made by Meynell and Sons Limited, Montrose-street, Wolverhampton, for a wide range of industrial applications where it is necessary to control the level of liquid in boilers, tanks, or other vessels. The level control has been designed for use in conjunction with electrically-driven pumps and incorporates the Teddington patented liquid-level switch (ENGINEERING, August 16, 1957). The unit is said to be particularly suitable for steam-boiler applications where it can be used for feed-water pump control and/or a low-water alarm and cut-out.

The principle on which the design is based is that heat is dissipated more rapidly through a liquid than through air or vapour. The liquid-level control switch comprises two probes, each consisting of an invar rod in a brass tube. The invar rod, which has a very low coefficient of expansion, is connected to the brass tube at one end, the other remaining free. Use is made of the different rate of expansion of the invar and brass in the operation of the control.

The invar rods bear on either end of a pivoted switch lever. One of the rods has a small continuously-heated electrical heater wound around it so that one probe is always hotter than the other. The other probe works in opposition to compensate for changes in the ambient temperature. When the probes are immersed in liquid the heat is dissipated very rapidly, and the difference in temperature between the two probes is not sufficient to operate the switch. When the level falls, however, and the probes are no longer immersed in liquid, the heat is dissipated at a much slower rate. This increases the difference in temperature between the two probes causing the switch to close the pump circuit.

Two versions of the control are at present available. One is suitable for controlling the water level of steam boilers having a maximum steam working pressure of 120 lb. per sq. in. and for the control of non-corrosive fluids at or near atmospheric temperature at a maximum working pressure of 350 lb. per sq. in. The liquid level in many applications can normally be controlled to within approximately ½ in., this factor, however, being dependent on the rate of liquid efflux. The switch will operate in 8 to 12 seconds of level change. The level control covers a wide temperature range from just above freezing point (provided that freezing point is not lower than − 22 deg. F.) to 350 deg. F.

The other version is available for operation where a rapid restoration of level is not considered essential or is not required at all. The switch in this case will operate in 32 to 38 seconds of level change. This model is not recommended for use with steam and should not be used where the maximum temperature exceeds 250 deg. F.

Management

Weekly Survey

Who Owns Steel?

A pamphlet put out by the British Iron and Steel Federation called *Steel Today: Who Owns the Steel Industry?* illustrates the wide dispersal in ownership. There are nearly 42,000 shareholders in Colvilles, over 30,000 in Dorman Long and 29,000 in United Steel Companies. The number then tails off to just over 4,000 in the case of Whitehead Iron and Steel Company. Nine out of ten shareholders own less than 500 shares each, and the ten largest shareholders own together an average of only 11½ per cent. of the total capital.

The largest shareholders are insurance companies, bank nominees, the Church Commissioners and pension funds—in that order. Together they account for less than 12 per cent. of the average capital. The Co-operative Insurance Society own steel shares and no doubt some of the trade union pension schemes do as well.

The obvious lesson is that the steel industry belongs to a large number of small investors. This disposes of the political argument that steel is in the hands of a small group of powerful men. It falls into the trap, however, laid by some Socialists that it will be used to show the divorce of ownership from power. It will be said that those who own the industry have no influence on it and that lack of power means indifference and irresponsibility.

Those who wish to use this exercise as an argument against the re-nationalisation of steel should draw attention, not to the large number of small investors, but to the holdings of pension funds and the co-operative movement and perhaps also to the useful number of employees' shares which now exist. In their capacity as pension fund administrators, the trade unions are just as likely to be favourably disposed to an efficient steel industry and good profits as any of the tycoons of mythology or the iron masters of yesteryear.

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Two Voices on Money

The annual meeting of the International Mo ne tary Fund and the World Bank in Washington opened last week with a faint flavour of anti-climax. The finance ministers of neither Germany nor France were present and the whole proceedings met under the shadow of the 2 per cent. rise in Bank Rate in the United Kingdom. With France and Germany represented only by officials, the way was clear for a top level exchange of views between this country and the United States without having to take account of too many Continental cross-currents.

It quickly became apparent that the attitudes of the United States and the United Kingdom on current international economic affairs are quite different. The Americans consider that the main problem is inflation not international liquidity. They produced figures early in the meeting to show that the dollar gap was being closed in the second quarter of 1957. Even before these figures were available the Americans had indicated that they considered current international currency problems to be mainly a domestic matter for the countries concerned. The United Kingdom prefers to consider that the problem is an international one arising from the hardness of the German mark and American dollar. According to the British the mark is seriously out of alignment with other world currencies. Meanwhile the British are going to draw on the 500 million dollars line of credit arranged in December and Mr. Thorneycroft has said that "the £ will be defended, if necessary at the expense of full employment."

If the British view is correct it will probably be necessary to increase the borrowing powers of the International Monetary Fund, a step which does not commend itself to the Americans. The fact is that the failure of the French and German Ministers to turn up at the meeting has dealt a severe blow to the prestige of the I.M.F. There have always been influential Europeans who took the view that the I.M.F. was an instrument of American policy and the meeting this year has done nothing to offset that view.

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Competition in Loans

One day, perhaps, when inflation and reckless spending have been stopped in Britain and when Sterling is once again the soundest and cheapest currency in the world, countries will come to London for financial aid. The events of the past few years do not, unfortunately, suggest that this is a likely event in the near future. One of our greatest traditional markets, India, has turned to the dollar and the West German mark for support. Rhodesia also is seeking a loan in the United States.

The Indian Government recently sent the Finance Minister, Mr. T. T. Krishnamachari, to Washington to negotiate a loan from the new 300 million dollar Economic Development Fund and from the Export-Import Bank. The Bank will lend dollars for the purchase of supplies for industrial projects; the International Bank is already helping with public works projects, such as railway and road development. The desire to keep India out of Russia's sphere of influence may lead Congress to pass a special aid programme which would match India's most ambitious development plans. But Germany has now begun to qualify as a lender on a world scale. The German Government and financiers have expressed their readiness to assist India out of her present difficulties and appear anxious to secure a financial foothold in that country.

This search for the United States dollar and the DM has serious implications for our exporters, for obvious reasons. Yet it is better that countries such as India and Africa should be able to industrialise and to raise living standards, for the effect on world trade is expansionist and therefore benefits us as the world's leading trading nation. The competition for loans which is developing is part and parcel of the wider competition for trade, and yet the political considerations which affect the policies of the countries concerned are not as unfavourable to this country as might appear on the surface. The presence of Russia on every scene ensures that the country in receipt of a loan will be left fairly free from any controls on how it shall be spent. To attempt to link loans too directly with trade would be politically most unprofitable.

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Fuel Thrown Away

The Third Progress Survey, together with the report and accounts of the National Industrial Fuel Efficiency Service was declared on Tuesday, September 17. It is a cheering one in that the Service continues to increase as more and more firms are becoming conscious of the pressing need to operate their plant at its highest efficiency. Heat and power surveys still form the largest part of the work carried out by N.I.F.E.S., and together with regular service agreements bring in the bulk of the revenue. In spite of the substantial increase of this, however (it has gone up from £38,813 to £95,289), it is still only a fifth of the expenditure, the rest has been met as before by subscriptions.

This report is the first to cover the new departure in fee-earning activities—that is the specific advisory service. This was instituted in response to the number of requests for information which, without calling for lengthy examination or instrumented surveys, required a high standard of technical experience to answer. Examples are the question of abatement of smoke and grit, the insulation and space heating of buildings, and the choice of new boiler plant. Other consumers have asked for checks of calculations of heat losses or of assessment of heat requirements. Immediate savings have been achieved in all firms which have made use of this service.

That the savings in fuel are really beneficial, not only to the conservation of National resources, but also to the firms concerned, the report states that 177 firms saved 122,000 tons of fuel per annum without any capital expenditure at all, merely by following the advice given as a result of the surveys. A further 100,500 tons were saved in 257 works at a total expenditure of roughly £1,026,000. The heat and power surveys carried out during the year showed that the savings which could be made in those cases averaged 18·4 per cent. of the total fuel consumption of the undertakings concerned. These figures go far towards showing that the Pilkington Committee's target of a coal saving within industry as a whole of up to 9,000,000 tons a year, is by no means an impossible achievement.

One section of the report deals in detail with the Government loan scheme, whereby loans are made available for most methods of saving fuel, provided that it can be shown that results will be substantial in relation to the expenditure. There is no limit to the cost of schemes eligible for consideration, but it is expected that an application will be made only if the firm is unable to secure funds from other sources. The loans are free of interest for the first two years after the fuel saving equipment has been installed.

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Variety and Standardisation

Among the most tricky tasks facing the managers of manufacturing concerns is to find out what to make and, even more vital, what not to make. Most managements are therefore concerned with finding new products which enable their company to keep up with changing markets, and to give them a spread sufficiently wide to provide stability. But something has also to be done to cut out the dead wood.

Variety reduction and standardisation were the subjects discussed at a seminar held in London last week under the auspices of the British Institute of Management in collaboration with the British Standards Institution. Some 25 people, including 20 senior managers in industrial enterprises, assembled to hear brief statements on the various aspects of the subject. Mr. T. R. B. Sanders, engineering adviser to the British Standards Institution, spoke on "Why Variety Reduction and Standardisation?" Mr. A. C. C. Moore, manager of one of G.E.C.'s factories, gave examples taken from his own experience of "Production Economies Achieved by Variety Reduction and Standardisation." The sales manager of Ilford Limited, Mr. R. S. Liddle, considered the marketing problems involved and, more specifically, of the "Sales Promotion of a Reduced Range of Products." The last talk of this one-day meeting was given by the group design manager of Joseph Lucas (Electrical) on "Standardising Product Design and Increasing Interchangeability." The chairman of the meeting, Mr. D. G. Johnson, chairman and managing director of Geo. Bassett and Company, the confectionery manufacturers, both opened and summed up the discussion.

From the interchange of views which followed emerged an interesting pattern of current thought and practice on variety reduction. Very briefly it is that variety cannot be eliminated without a clear understanding of its *raison d'être*; that it is often useful and that even when its usefulness is questionable its elimination presents difficult problems; that the task on hand is to "optimise variety" rather than to cut it right out. Nonetheless few of those present questioned the necessity of a constant examination of a company's range, component by component, to ensure that none remains which does not fill a distinct market

Continuing Management

need. The economies in costs achieved in this manner and quoted at the meeting—ranging from 20 to 80 per cent.—are such that no company can afford to neglect this task and yet compete in world markets.

* * *

The Machine Minders by Miss Ghisha Koenig.

PORTRAIT OF THE CRAFTSMAN

Photography is far and away the most efficient way of obtaining a pictorial record of engineering work in progress and completed. For utilitarian purposes—technical, publicity, advertising, etc.—it is unrivalled, but if painting or sculpture is used the record is endowed with a lively quality which few photographs can equal. The sense of achievement in engineering is a fleeting experience; the spirit which inspires a team is dissolved by time; future generations will be left with only the technical facts, but facts are no more than half the stuff of experience. How leave a record that is imaginative—that will be preserved for its own sake as well as for the idea or event which it records? Years after Alcock and Brown had become the first men to fly the Atlantic a sculptor was commissioned to commemorate the two men in stone. The blasé traveller walking across the tarmac at London Airport now stops for a moment and is humbled.

There must be many opportunities for a sculptor in a workshop or on a construction site. A craftsman, a woman doing delicate work, a group of two or three men working together—there is surely as much scope with these as with the subjects traditionally chosen by artists. A sculptor who believes there is such an opportunity is Miss Ghisha Koenig, who has obtained permission to practise her art in several factories. "The Machine Minders," illustrated on this page, depicts a couple of men who might be thought to be soul-destroyed were it not for their somewhat whimsical appearance. In some cases she includes more of the machine than just a handwheel; for example, a mixing machine with the operator pouring in the contents of a large can of liquid. She remarks, incidentally, that until she had entered a factory she had always imagined that machines were designed to suit the physical characteristics of the operators, but now she is surprised how frequently the man or woman has to arrange a box to stand on, or some other expedient to make the work comfortable. Artists notice details of this kind, though they do not fully understand the technicalities of the machine. It is perhaps for this reason that painters and sculptors can capture, and enshrine for posterity, something that is missed by the verbal and photographic log of contemporary industry.

Marketing

ENGINEERING FIRMS IN THE FREE TRADE AREA

10—DEMAG A.G., DUISBURG

The name of Demag is associated with mining machinery and complete plants for ferrous and non-ferrous metal production. It is also known for heavy conveying equipment, including cranes and a wide range of general engineering equipment. Of all these it has probably had most publicity in this country for its competition in overseas markets for complete steelplant units. In places as far apart as Korea and India on the one hand and South America on the other, Demag by itself, or as a leading member of a consortium, has offered severe competition to its British counterparts. This publicity is justified for more than one reason, as it is this steelplant side of Demag's activities which makes most of the company's profits. For this reason and for limitations of space it is Demag's competitive strength in supplying equipment to the metallurgic industries which is mainly dealt with in this article.

There is acute competition in all markets, including those affected by the European Common Market and the Free Trade Area. In the recent past Demag has installed the largest ore transporter in Continental Europe at Narvik, Norway, and has this summer booked an order for a new steel mill in Finland. There has been much recent publicity about its success in obtaining a large order from Portugal against competition from Britain. Finland and Portugal are not likely to be members of the Free Trade Area, at least in its early days, but they illustrate the ability of Demag to compete effectively in Europe as a whole. It is possible that the introduction of the European Common Market and its gradual tariff disarmament will increase Demag's competitive power in France, Italy, the Netherlands, Belgium and Luxembourg and that this increased effectiveness will spill over into the United Kingdom market.

Like all makers of steel producing equipment, Demag has lived in a different kind of world since the war compared with the 1920's and 1930's. World steel capacity continues to expand and the industry's policy is one of large-scale investment and a greater willingness to scrap-and-build than a generation ago. The European steel-equipment industry has thus been operating for the last 10 years or more on an expanding market.

The exports of German rolling mills and auxiliary machinery between 1954 and 1956 are given in Table I. It shows that, despite the large amount of publicity given to Demag's contracts in the East and in South America, the big market in the recent past for the German rolling mill industry as a whole has been in Europe with the inference that this market is still important. It will be observed too that the total has not expanded over these three years, and that deliveries to individual countries have varied considerably from year to year. It has to be remembered, however, that changes from year to year in equipment of this size are not always indicative of a trend. Large steel mills take something like two years to fabricate and statistics of production therefore suffer from the same kind of limitations as those for shipbuilding.

The German export statistics for furnaces, ventilators and blowers show by contrast a slightly upward trend while those for ancillary equipment for foundries and steel works show a pronounced increase as can be seen from Table II.

The United Kingdom export figures have a somewhat similar appearance. These are set out in Table III, which shows exports of steel-making equipment in the last three complete years.

It will be noticed that exports of complete rolling mills have fallen off in value whereas the exports of other equipment have increased. To give a comparison between the German and English figures it is necessary to add the second and third items together in Table III. When this is done the same fairly stable level of exports is found in both countries, although the value of German exports is about double the English. This is not surprising since it is one example among many of Germany taking the lion's share by tradition of the Continental market for heavy engineering equipment.

MARKET PROBLEMS

As might be expected, Demag's turnover, being dependent upon the demand for new metal capacity and heavy conveying equipment, has moved ahead rather more quickly in recent years than the output of West German industry in general. Between 1950 and 1955 West German industrial output went up by 172 per cent., whereas Demag's sales went up by 203 per cent. In 1954 home market orders accounted for about 60 per cent. of Demag's output but by 1956 the export ratio had gone up to 60 per cent. and the home market had dropped back to 40 per cent. In the spring of 1957 export orders had increased to 68 per cent. of turnover of which 50 per cent. was for countries outside Europe. On the whole, therefore, the impetus behind the rise in Demag's export business is now from outside Europe. This represents a comparatively larger rate of increase in capital investment overseas than in Continental Europe, but it

TABLE I.—*German Exports of Rolling Mills, Tube Rolling Mills, Auxiliary Rolling Mill Appliances*

£000

1954		1955		1956	
Total	11,900	Total	6,440	Total	10,720
Of which the principal importers were:					
Luxembourg	2,610	Luxembourg	780	Belgium	1,560
Yugoslavia	1,520	Italy	730	Spain	1,420
Italy	1,200	Spain	650	Italy	1,390
Japan	1,090	Yugoslavia	630	Saar	890
Switzerland	840	Brazil	610	Austria	790
Brazil	780	India	510	Canada	750
Belgium	480	France	470	India	620
France	450	Belgium	410	Egypt	400

TABLE II.—*German Exports of Miscellaneous Steel-Making Equipment*

£000

	1954	1955	1956
Miscellaneous ancillary equipment	3,680	4,040	8,900
Industrial furnaces and ovens (excluding electrical plant)	2,300	3,000	3,920
Electric furnaces and ovens	1,470	1,800	2,400
Ventilators, blowers, etc.	1,800	1,770	2,720

TABLE III.—*United Kingdom Exports of Equipment for Steelworks and Non-Ferrous Metal Plant*

£000

	1954	1955	1956
Cold drawing plant for bars and tubes and tube-making machines other than extrusion presses	226	255	201
Rolling mill (metal-working) machinery:			
Rolling mills (hot and cold)	3,035	2,393	1,297
Rolls of iron or steel for metal rolling mills	2,794	2,966	3,778
Furnace plant (non-electrical):			
Blast furnace plant	350	1,728	857
Other metallurgical furnaces and appliances	1,054*	769	955
Electrical furnace plant	—	693	726

* Includes figures for electrical furnace plant.

does not mean that Demag's competitive power in Europe has been impaired. The figures do suggest, however (when taken in conjunction with those in Table I), that Demag is more concerned with overseas markets than other German rolling-mill fabricators.

It is possible that Germany's challenge may be somewhat blunted by rising costs to judge from the history of labour relations over 1955 and 1956. Between these two years the labour force went up at Demag from about 20,000 to 22,000. During 1956 a 45 hour week was introduced without loss of wages resulting in a loss of production on a time basis which was equal to about 1,450 workers, say 7 per cent. To restore this cut in output would cost about DM14·5 million, or about £1·3 million. A series of wage and salary increases over 1955 and 1956 added to the rising cost of overtime coming from the introduction of the 45 hour week is estimated to have put about 9·7 per cent. on to wage and salary costs. Altogether, including the increased cost of raw materials, production costs in 1956 increased by between 7 and 8 per cent. The company has also complained that the abolition of the special export-promotion tax relief at the end of 1955 increased the liability for taxation and appreciably reduced profits. It is difficult to say how this overall increase in costs has been spread, however, between the different branches of engineering.

In the last few years the five European countries (which with Western Germany make up the European Common Market) have taken about 10 per cent. of Demag's turnover. This includes conveying and handling equipment. One suspects that the percentage of rolling-mill equipment going into the five countries was rather higher. The company has gone on record with the opinion that the establishment of the Common Market is not likely to result in a sudden expansion of business. This is only to be expected. Obtaining a contract for a rolling mill or a heavy piece of conveying equipment may take anything up to five years and is tied much more, in the first case, to the long-term rate of expansion of the steel and non-ferrous metal industries than to short-term aggressive salesmanship.

In the European Common Market and also in the Free Trade Area, Demag will probably rely on steadily building up the pressure on the sales side by developing its consulting services. The company lays considerable store by its cadre of engineers with knowledge of world-wide conditions for the siting, erecting and running of steel plant. It has encouraged steelmakers as well as governments who are planning integrated plants to use its consulting services, having organised these into divisions for this purpose. Thus there is one for integrated plants and one for mineral exploration as well as a steel works division. This, naturally, brings in consulting fees but it is also bound to influence the basic planning of the location and erection of the iron and steel works in favour of Demag equipment.

Scale of operation may be a key factor for Demag in the years ahead. It is, in a sense, an "iron and steel consortium" in itself, competing, so far as this country is concerned, against a more "fragmented" industrial structure. It has to be noticed that Demag operates on a larger scale than, say, either of its two best known British competitors on the rolling mill side of its activities. At the end of December, 1956, Demag's fixed assets were valued at DM90 million excluding participations in other companies, or about £8 million, compared with fixed assets of Brightside Engineering Holdings Limited of £700,000 and Davey and United Engineering Company, Limited, of £1·7 million. Methods of accounting may differ here and in Germany, especially as regards payment for contracts in hand, and a substantial allowance has to be made for the fact that Demag produces a wide range of other equipment as well as steel-mill plant. Even when allowance is made for these, however, the disparity in the size of the fixed assets, is considerable. To judge from published figures on profits the same large differences show on turnover. Demag's annual turnover in 1956 must have been about £50 million, compared with Davey and United or Brightside at, say, £7 million to £8 million. A number of its services which give it valuable long-term selling potential can thus be spread over a larger and more varied output. With a discrepancy in size of this sort it is quite clear that there is strength in numbers on the British side and that the consortium technique must be used wherever possible in meeting German competition. It requires a complete range of experience in the siting and fabrication of integrated steel mills to fight German competition on this scale. Demag themselves, of course, use the consortium technique as, for instance, in the recent Portuguese contract, in this case the German company uniting with Belgian interests.

OTHER ACTIVITIES

Demag's sheer size may give it an element of flexibility in the Common Market. Although there is reason to think that the activities connected with the installation of rolling mills are the most profitable and from the point of view of prestige most important aspects of the group's activities, the complete range is impressive. The company manufactures a wide range of conveying and site-levelling equipment for the mining industry. Its work for the metallurgic industries includes not only complete major units such as furnaces and hot and cold strip mills, but also a wide range of ancillary equipment. On the more general engineering side it makes centrifugal pumps, compressors, cranes, generating sets, stoking equipment, steam engines, storage tanks and steel structures. For the chemical industry it makes a wide range of equipment from condensers and cooling systems to electrolytic plants for the production of chemicals.

On the civil engineering side it offers a wide range of civil-engineering equipment from concrete mixers to pavers and it also has an interest in such fields as Diesel engines and gear wheels. These widely varying activities offer the company a wide range of alternative lines of expansion if it can get the capital and the manpower to use them. Tactically, it may prefer to concentrate for some time on providing plant for the metallurgical industries since it is highly profitable and the world market continues to grow. It is possible too that the expansion of its more general engineering activities in Europe may be limited by a growing appreciation of quality. In civil engineering equipment, for example, German equipment is known to be highly competitive on price, but less competitive than British equipment on quality and there have been signs of late that the Continent (even the German market) is appreciating quality to a growing extent.

FOREIGN AGREEMENTS

So far as technical development is concerned, Demag has a working arrangement with a group in the United States in the same way as Davey and United have had connections with the United Engineering and Foundry Company of Pittsburgh since the 1930's and an even older working arrangement with the Morgan Construction Company. One of Demag's 17 subsidiaries, the Demag-Electrometallurgie G.m.b.H., of Duisburg, made an agreement at the beginning of 1957 with the Lectromelt Furnace Division of the McGraw-Edison Company of Pittsburgh, who make electrical furnaces and induction-heated melting furnaces. This agreement will enable each partner to supply products in its traditional markets to either its own or to its partner's design. There are other similar arrangements, notably on the tube mill side, covering both ERW and seamless tubes. Partnership agreements exist with Actua Standard Engineering Company, the Abbey Etna Company and E. W. Bliss.

Demag is increasingly using training facilities as a means of widening its foreign contacts In 1955 there were 177 trainees from abroad, all being foreign technicians and apprentices, under instruction in connection with large-scale contracts won by Demag for steel plant construction. A year later, in 1956, the number had increased to 300. So far as the European Common Market and the Free Trade Area is concerned it should be increasingly easy to interchange technical personnel over national borders either to act in a consulting capacity or to be trained. Although the "harmonisation" of wages will probably be a complicated issue in the administration of the European Common Market (it will also be so for the Free Trade Area if it comes into existence), there are already precedents for the international transfer of labour in the metal-forming industries in the recent decision of the Iron and Steel Community to make it possible for workers to move from the steel industry in one country to that in another. The interchange of trained personnel, the movement of trainees across borders and the establishment of international consortia are all likely to be facilitated by the Common Market. It follows, therefore, that if the Free Trade Area is delayed, the German companies, among which must be numbered the formidable Krupps group as well as Demag, will have a flying start so far as the mobilisation of technical knowledge and training contacts are concerned.

In the winning of contracts for this kind of work, much may depend on credit terms and progress payments. In its latest annual report Demag complain of the excessive risks which they have to carry in the export trade and of the need for better long-term finance facilities. It says that only in a few cases was the company able to give special terms to customers and that, on the whole, the credit facilities which it can offer are inferior to those available to foreign competitors. A certain amount of this may have been written for overseas consumption, especially in this country, for it is not generally considered here that the Germans have to offer worse credit terms than British suppliers.

Demag's challenge in the Free Trade Area is, to sum up, of two kinds. It brings a wealth of experience in salesmanship and technical matters to the provision of metallurgical equipment. The market for this equipment is still growing throughout the world as the steel industry expands and Demag's resources and energies may be absorbed to a considerable extent in further developing this side of the group's activities while capital and labour are scarce. The attractiveness of catering for a very wide range of engineering products in a large European market free from tariffs may, however, tempt Demag to increase its challenge in any or all of these fields as time goes on either by reducing its prices or raising the quality of its products. Diversification will represent strength as the European Common Market and the Free Trade Area come into existence provided that at least some outlets are highly profitable. A company such as Demag has the tactical advantage of being able to move its investment from one group to another as circumstances may dictate. It cannot be assumed that the company's big interest in overseas business will indefinitely limit its interest in the European market, for success overseas may bring profits which can be invested in general engineering capacity. The challenge of Demag is probably forseeable for the next four or five years, after that it is not possible to say more than that it will be substantial and possibly widespread.

★ ★ ★

Rainwater, soil and flue-pipe fitments of asbestos cement are now being pressure-moulded to give a product of a much higher dimensional accuracy than hitherto. In manufacture the wet asbestos cement is placed around a flexible rubber core and then put into a phosphor-bronze master mould; the core is inflated by hydraulic pressure and the asbestos cement is fully consolidated.

This process of manufacture, applied to such a material, is of Italian origin and is being used under licence by the Universal Asbestos Manufacturing Company, Limited, Watford.

Research and Development

"CORPORAL" MISSILE WAS DEVELOPED BY UNIVERSITY RESEARCH

In the United States, university research receives substantial support from the Government, to the extent of 71·4 million dols. during the last fiscal year; and, on the aeronautical side, industry also is playing a smaller but increasing part in fostering university research. These trends were discussed at some length in the 45th Wilbur Wright Memorial Lecture given recently, before the Royal Aeronautical Society, on "Advanced Education and Academic Research in Aeronautics," by Dr. Clark B. Millikan, director of the Guggenheim Aeronautical Laboratory, California Institute of Technology. We give below a summary of Dr. Millikan's description of some of the Government researches carried out, and in progress, at "Cal. Tech."

G.A.L.C.I.T.

The Guggenheim Aeronautical Laboratories, which house the graduate school of aeronautics of the California Institute of Technology, have been working on problems in solid and fluid dynamics.

Certain missile structures call for cylinders stiffened only by rings and without longitudinal members. Fig. 1 shows two of a large family of such cylinders which have been tested, and clearly indicates the interesting types of failure pattern which are observed. This study has been supported by the Ramo-Wooldridge Corporation. A second programme, sponsored by the N.A.C.A., is an investigation of the fundamental parameters underlying the fatigue of metals, the relationship between internal damping (as measured by a long rod used as a torsion pendulum) and temperature, stress, frequency of stress application, and number of stress cycles. Inter-crystalline slip changes the internal damping and thus furnishes a measure of fatigue damage.

In fluid mechanics, investigations cover the range of Mach numbers from the essentially incompressible to the hypersonic regimes. In the intermediate Mach number range, a study of the noise produced by turbulent boundary layers flowing over solid surfaces is sponsored by the N.A.C.A. In one experiment the fluctuating forces exerted on a wall by a high-speed turbulent boundary layer are measured with Piezo-electric pickups. In a second, a low noise-level turbulent pipe flow passes through a very thin-walled (down to 0·001 in.) cellophane tube. The acoustic field is measured in a heavily insulated chamber surrounding this tube.

Also supported by the N.A.C.A. is a study of acoustic radiation from cut-outs in aerodynamic surfaces, which was recently completed. Fig. 2 is a schlieren spark photograph showing the acoustic field radiated from the cut-out at a Mach number of about 0·8.

Studies dealing with cylindrical shock waves are supported by the Office of Naval Research. The apparatus is essentially a lucite circular cylinder along whose axis a thin wire is exploded by a powerful electric discharge. A cylindrical shock, initially very strong, travels outward to the wall and is then reflected back to the centre Here it reflects again and the process is repeated. It is hoped that it may be possible to re-energise the shock by repeated discharges through the ionised gas region along the axis.

Turning finally to the high Mach number area, the Army Ordnance Corps has for many years supported the design, construction, and research operation of a small hypersonic wind tunnel facility. The compressor plant required for continuous operation of a wind tunnel at Mach numbers up to 10 is necessarily extremely complex and elaborate. The closed circuit can be completed by either of two test sections, called Legs 1 and 2, each having a cross-section about 6 in. by 6 in. Leg 1 has a maximum stagnation temperature of about 300 deg. F. and fixed nozzle blocks giving a Mach number of 5·8. Fig. 3 shows a blunt body model mounted in Leg 1 with one nozzle side plate removed. Leg 2 includes an electric heater giving a maximum stagnation temperature of about 1,150 deg. F. which should permit condensation-free operation up to Mach numbers of 9 or 10. This high temperature requires that the throat, adjustable nozzle, test section, and diffuser be water-cooled, and results in an extremely complex installation. Fig. 4 shows this Leg 2, which was constructed by the Jet Propulsion Laboratory as a scale model for a larger hypersonic tunnel, to be mentioned later. The photograph shows the model tunnel during its initial test and calibration. Some of the subjects studied under the available hypersonic flow conditions have been flat-plate boundary layer characteristics (including skin friction, heat transfer, and laminar-to-turbulent transition), heat transfer to figures of revolution using both transient and steady-state techniques, thick boundary layers on thin circular cylinders in axial flow, film cooling, flow fields around both slender and blunt figures of revolution, and so on.

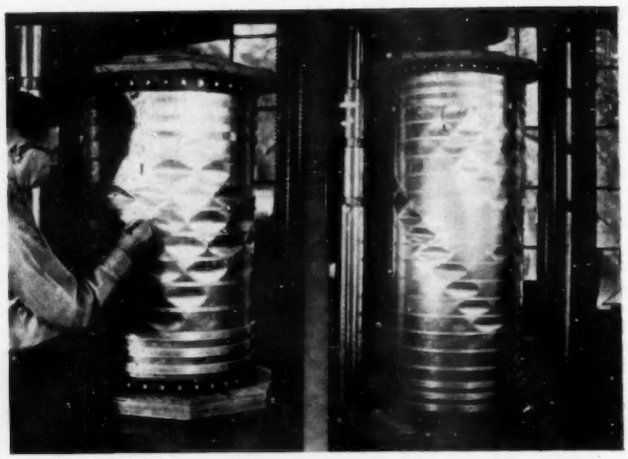

Fig. 1 Test specimens of ring-stiffened cylinders that have been loaded to failure.

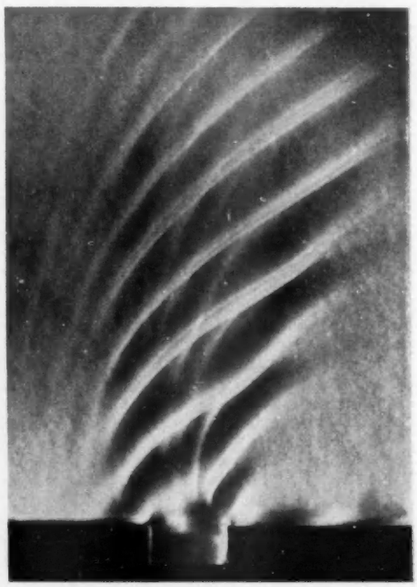

Fig. 2 Acoustic field radiated from a cut-out in an aerodynamic surface at Mach 0·8.

JET PROPULSION LABORATORY

The Jet Propulsion Laboratory has grown from an extremely modest beginning in 1936, when a few graduate students at the G.A.L.C.I.T. initiated studies of rocket power plants and rocket-propelled vehicles. In 1939 the Army Air Corps Jet Propulsion Research Project was established with Dr. Theodor von Kármán as its first director. For the next few years the chief emphasis was on the development of solid and liquid propellent rockets for Jet Assisted Take-Off (J.A.T.O.) of aircraft. In 1941 the first successful J.A.T.O. flights in the United States were accomplished with small solid propellent rockets on an Ercoupe monoplane. The following year a Douglas A-20A bomber was fitted with two much larger liquid propellent rockets and made numerous highly successful J.A.T.O. flights.

At the direction of the Army Air Corps, the Aerojet Engineering Corporation was established to undertake the manufacture and commercial development of these J.A.T.O. units, and the G.A.L.C.I.T. group turned its attention to other jet propulsion researches. At the request of the Army Ordnance Corps, the development of rocket-propelled ballistic missiles soon became the central core of the project's varied activities, and in 1944 a reorganisation was effected whereby Army Ordnance took over ownership and sponsorship of the project, which was then established as the Jet Propulsion Laboratory. In the past 15 years its growth has been quite extraordinary until now it occupies 80 acres and employs some 1,900 persons, of whom nearly 30 per cent. are professional engineers and scientists.

The first J.P.L. missile was an uncontrolled solid propellent rocket called the Private A. It was launched by a solid propellent booster, stabilised by fixed fins, and powered by a motor giving a 1,000 lb. thrust for 30 seconds. Its flights, starting in 1944, provided valuable aerodynamic data. The second missile, called the WAC Corporal, was designed to carry a 25 lb. payload of meteorological instruments for upper atmosphere investigations. Also boosted by a short-duration solid propellent rocket, its motor was of the liquid propellent type, utilising red fuming nitric acid and aniline. In 1945 it established an American altitude record of 43½ miles. Fig. 5 shows the Bumper-Wac, a two-stage high altitude research vehicle in which the WAC Corporal was fired from an altered German V-2 used as a first stage. This combination in 1949 reached an altitude of 250 miles which, so far as is known, remained the highest altitude attained by a man-made device until very recently.

The next in the series of J.P.L. missiles was the Corporal, originally designed as a fully guided research vehicle having considerable range and a very substantial payload for research instrumentation. Its flight performance suggested that it could be developed into a tactical missile

capable of carrying a nuclear warhead. The Laboratory was assigned the responsibility for this development, which culminated in early 1954 in the acceptance by the Army of the liquid propellent Corporal as the country's first long-range tactical supersonic guided missile. Following completion of the Corporal programme and the transfer of responsibility to industrial firms for its quantity production, the Laboratory was assigned the job of developing a much improved ballistic missile system, the Sergeant, on which it is currently working. J.P.L. has also contributed significantly through its supporting researches to several other of the country's guided missiles.

Of all the supporting and basic researches which underlie this missile development programme, only those in one field, aerodynamics, can be mentioned. The facilities here include a 12 in. supersonic tunnel reaching a Mach number of 4, a 20 in. tunnel attaining a Mach number of 5, and a 20 in. hypersonic tunnel designed for the Mach number range from 4·5 to 8·5, which is currently under construction. A three-eighth scale model of the water-cooled adjustable nozzle and test section of the latter is currently under test as Leg 2 of the G.A.L.C.I.T. hypersonic facility, as was mentioned earlier, and will remain as a G.A.L.C.I.T. research tool when the tests are completed. The two supersonic tunnels have been used for hundreds of development type tests on many United States supersonic missiles, but have also been utilised in important unclassified basic researches on skin friction, boundary layer stability and transition, turbulence in supersonic flow, and so on. The Aerodynamics Division has also carried out theoretical and experimental studies of supersonic wing characteristics, missile stability and dynamics, real gas effects such as dissociation and ionisation which occur in hypersonic flows, and many other aspects of modern gas dynamics.

Dr. W. H. Pickering, the Laboratory's distinguished director, has succinctly expressed the basic *raison d'être* of the J.P.L. as follows:

> "The past two decades have seen the military strength of America become increasingly dependent upon the foresight and ingenuity of its scientists. To-day, the majority of the outstanding scientists of this country are contributing a part or all of their talents to the common defence. Developed for this purpose, the Jet Propulsion Laboratory is an especially significant example of a new type of organisation: the university-operated Government-owned installation, which has proved to be the most satisfactory method for providing the civilian scientist with the opportunity of working on the defence team."

In addition to filling this need the J.P.L. has also made important contributions to the academic life of its parent institution, the California Institute of Technology.

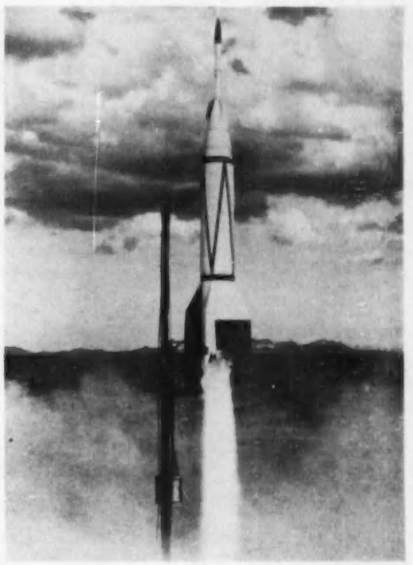

Fig. 5 The Bumper-WAC two-stage high-altitude research vehicle is launched on a flight to 250 miles altitude.

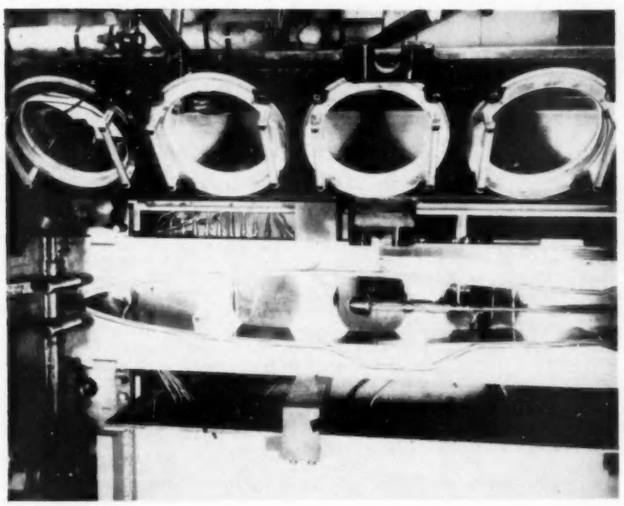

Fig. 3 Mach 5·8 hypersonic test section, with side plate removed and a blunt body model installed.

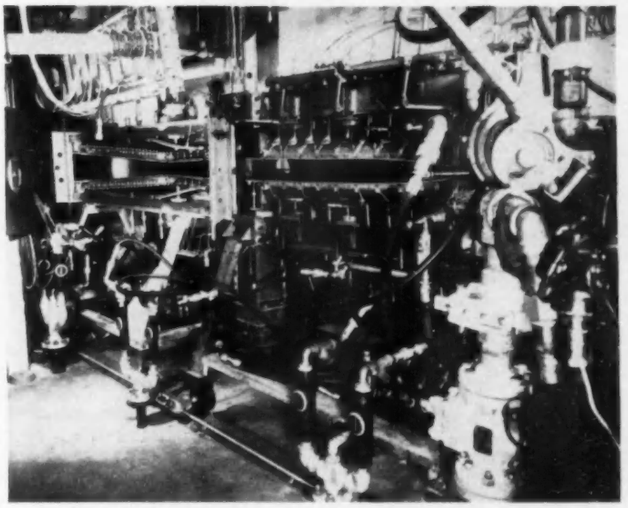

Fig. 4 Variable Mach number water-cooled hypersonic nozzle, test section and diffuser, with side plates removed, for speeds up to Mach 10.

AREA HEATING ELEMENT USING GLASS FABRIC BASE

A resistance material suitable for heating surface areas evenly has been produced by applying a very thin coating of graphite to glass fabric. The material, Mhoglass, was developed by A. J. Kemp, Sons and Company, Harlow, in collaboration with Hunting Percival Limited, Luton Airport, Bedfordshire. It is made in sheet form as continuous lengths 1 ft. wide. Usually it is supplied in 3 ft. to 4 ft. lengths or as completed elements with sprayed metal contacts.

Mhoglass was developed as a result of an investigation into the possibility of heating surface areas at comparatively low temperatures, ranging from a few degrees above normal ambient up to about 200 deg. C.; the power supplies available varied between 2 and 250 volts. Metals could not be used as their resistivity is far too low for them to be used as foils or closely woven mesh.

Graphite deposited on a base of glass fabric was chosen. Variations in element resistance, which is expressed in ohms per unit square, is attained by varying the number of coatings on the glass fabric. However, even for resistances as low as 7 ohms per square, the overall thickness of the deposit is of micro dimensions. Normally, elements are made in resistances of from 6 to 100 ohms per square, but in special cases the limits can be exceeded. In practice, most requirements for elements can be met from standard resistances by variations in contacting, which is achieved by means of sprayed metal. In this way, by series or parallel contacting, very high or low resistances can be got, as well as three-phase connecting and sprayed circuiting.

After processing, the element is treated with one of a selection of thermo-hardening resins—to protect the deposits of graphite. The resin is selected to suit the use to which the element is to be put and the operating temperature. Normally resins of the epoxy type are found to be most satisfactory.

The resin coating sets the limit to the temperature at which the element may run. However, it allows the element to be used in potting techniques and laminating processes, which may be employed without affecting the resistance of the element.

The material can be curved down to radii of 1 in. Alternatively, it can be curved during manufacture to radii of ¼ in. On the Hunting Percival Jet Provost aircraft an element rated at 20 watts per sq. in. has prevented icing up of a 1 in. diameter ram intake; and a muff-type heater is used to supply heat to a non-return valve, also in the fuel system.

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Many factory processes involve working conditions which may be uncomfortable or dangerous and, with the primary aim of examining means to alleviate these circumstances, a series of eight lectures on "Environmental Hygiene" is being arranged by the National College for Heating, Ventilating, Refrigeration and Fan Engineering at the Borough Polytechnic, Borough-road, London, S.E.1, on Friday evenings, commencing at 7 p.m. The fee is £1 and the first lecture is being held on October 4.

Continuing **Research and Development**

A SURVEY OF DEVELOPMENTS IN TELECOMMUNICATION*

By R. J. Halsey, C.M.G., B.SC.(ENG.), F.C.G.I., D.I.C., M.I.E.E.†

In the last two decades the techniques of telecommunication have been greatly refined and developed, incidence on the public services in the United Kingdom falling broadly under three headings:—
(*a*) technical improvements in transmission and switching;
(*b*) integration of existing services and provision of new ones within a common plan; and
(*c*) mechanisation aimed, eventually, at giving all subscribers access to the national network without intervention of an operator.

Evolution has been gradual and still continues; important milestones in the development of services in this country, prior to 1939, include:—
(1) the opening of the first automatic telephone exchange in 1912;
(2) the first use of valve amplifiers during the first World War;
(3) the opening of a commercial transatlantic radio-telegraph service in 1908, consequent upon Marconi's successful experiments in 1901; radio-telephony followed in 1927;
(4) the introduction, about 1920, of modulated carrier-wave transmission over lines; thus more than one conversation over a pair of wires became possible, leading to the modern art of carrier telephony on which long-distance line communication now primarily depends;
(5) the introduction, in 1928, of the teleprinter, operating on a start-stop basis and with a keyboard requiring only typewriting skill;
(6) the introduction, in 1932, of multi-channel alternating-current (voice-frequency) telegraphy over telephone circuits to replace individual direct-current connections; this was a valuable step in the integration of services;
(7) the introduction, in 1939, of arrangements whereby a trunk operator could dial a subscriber directly over a trunk circuit.

The key to the economic development of a communication network is to make maximum use of all the facilities provided by sharing them in the widest possible sense. A number of persons normally share a telephone instrument; two or more households often share their line connection to the local exchange; the need for sharing long-distance circuits is obvious. Sharing of facilities in this sense involves a probability of plant being unavailable; a caller may have to wait for a call box or a long-distance circuit to become free. Less obviously, he might also fail, at first attempt, to complete a call because a particular rank of switches in an exchange is fully engaged. The probability of such failure, in the busy hour, is known as the grade of service.

Most of the capital investment in telephone plant is in the lines and equipment which are individual to subscribers, and economies in this field will always be more rewarding than economies in common equipment. For example, the loss of signal strength over a connection must be within prescribed limits and the most economical allocation of losses is little or nothing in long-distance circuits, where utilisation is greatest, and the maximum permissible in subscribers' lines where utilisation is least. Improvements which occur from time to time in the design of telephone instruments and in exchanges are therefore best absorbed in cheapening the connections to the local exchange, for example, by using less copper or extending the service area.

The low-loss trunk and junction circuits required by the above considerations are provided either by coil loading (over short distances) or by fitting amplifiers at regular intervals. Within certain limitations such amplifiers can compensate almost completely for the line losses and permit the use of smaller, cheaper conductors. When amplifiers are arranged to provide a wide transmission band—the wider the band, the closer must be the spacing—more than one telephone circuit can be provided by multiplexing; this normally takes the form of frequency-division multiplex, i.e., carrier telephony. The principle of sharing plant thus arises again, this time without affecting the grade of service.

In making the present survey of developments it is necessary to fix a starting point and it is proposed to do this by outlining briefly the conditions which obtained in 1939. The paper will then deal with developments which have taken place since 1939 and, finally, we shall attempt to glimpse into the future. Throughout, we shall be primarily concerned with telecommunication networks and, in particular, with the public services in and to the United Kingdom.

* Paper read before Section G of the British Association at Dublin on September 10, 1957.

† Assistant Engineer-in-Chief, General Post Office.

THE PUBLIC NETWORK IN 1939

The interval between the two World Wars saw automatic telephone exchanges firmly established in Great Britain. By 1939 there were 3¼ million telephones served by 5,693 local exchanges, of which 2,925 were automatic. The endemic telephone problem of London had been solved by the introduction, in 1927, of a director system in which many automatic exchanges are linked together in a common-numbering system while, at the same time, complete flexibility in the routing of calls is preserved. Seven digits are employed, the first three being code digits identifying the exchange by letters; in the director these code digits are translated into routing digits in accordance with current engineering and traffic requirements. The ultimate capacity of this system is, perhaps, six million lines. Other applications of automatic switching extended right through the system to small Unit Automatic Exchanges with a capacity of only 100 lines and to Country Satellite Exchanges with only ten lines. In every case switching was performed mechanically by relays, uni-selectors and two-motion selectors.

On inland trunk cables two-wire amplified circuits with their troublesome line balances had given place to four-wire circuits of negligible loss and the hey-day of inductive loading, based on the work of Heaviside, was past; audio-frequency transmission was ceasing. Economics demanded that, over long distances, a pair of wires must provide many circuits, not just one. The art of carrier telephony had advanced slowly at first—one, then three, extra circuits on the open-wire lines which had only managed to survive on the fringes of the network; one extra circuit on a cable pair. The principles of amplitude-modulation and the subsequent suppression of one sideband together with the carrier frequency itself had led to the conception of frequency translation of signals.

Then came the epoch-making invention of negative feedback in 1933. This gave the transmission engineer means to stabilise the performance of his amplifiers and, much more important, means for the positive control of linearity, so essential to minimise mutual interference between the channels of a multi-channel system. With the aid of this new tool, the success, in 1937, of the first all-carrier cables, providing 12 channels over each pair in the frequency range 12 to 60 kc/s, was assured; without it the problems would probably have been insuperable. By 1939 such cables, with unattended repeater stations spaced at 22 miles, formed the normal basis of provision of long-distance circuits and plans for an increase in the number of circuits to 24 per pair, with repeaters spaced at 16 miles, were in hand. International agreement had been obtained on the 4 kc/s-spacing of telephone channels and the quality of the channels so derived had been greatly improved by incorporating piezo-electric resonators in the channel-separating filters. Finally, the next major step had been taken; a coaxial cable had been laid between London and Birmingham and equipped for broad-band transmission with repeaters spaced at 8 miles. This was planned to transmit a frequency band 0·5 to 2·1 Mc/s and to provide, ultimately, 320 channels at 5 kc/s spacing. In 1938, one super-group of 40 channels was provided on this basis and others were added later. The frequency pattern was, however, abandoned when international standards were agreed.

Prior to 1937, submarine cable telephony, e.g. to the Continent, had been at audio-frequencies, though a few carrier circuits had been superimposed. In 1937, a pair of coaxial cables had been laid between England and Holland using a new dielectric, para-gutta, and providing, initially, twelve circuits—a number which was doubled before 1939; similar cables were laid to Ireland and the outlying islands.

In trans-oceanic cable telegraphy there had been little spectacular advance in the previous 50 years; cables were operated on a d.c. basis at speeds which had been slowly increased but which were close to the theoretical limits imposed by noise induced in the shore ends. A few of the latest cables used continuous inductive loading which had permitted valuable increases in signalling speed. Trans-oceanic cables were in technical competition with radio and a number of short-wave telegraph circuits spanned the oceans. This state of affairs had led to the formation, in 1928, of Cable and Wireless Limited to operate the two types of service.

For trans-oceanic telephony, 17 radio circuits provided world-wide service but, even when the vagaries of ionospheric reflections were mitigated by single sideband operation and high-gain steerable receiving antennae, it was impossible to provide full service; technical operators were required. The longest submarine telephone cables were little more than 100 miles in length, at which order of distance they became uneconomic. Nevertheless, a trans-atlantic telephone cable, to provide one circuit, had been discussed in 1928 but the project was abandoned on account of the economic depression and the advent of short-wave radio.

Using multi-channel voice-frequency telegraphy, the inland telegraph network had been integrated with the telephone network. The system was essentially one of point-to-point links although there were plans for automatic switching. A telex service, based on 1,500 c/s transmission over switched public telephone circuits was in restricted use both internally and to the Continent; this enabled connections to be established between subscribers equipped with page-type teleprinters. Transmission of still pictures (facsimile) was fully developed and in use over four-wire connections, mainly for Press purposes.

Several multi-channel VHF radio-telephone systems, e.g., to Jersey, formed part of the internal network and there were also a number of VHF phonogram links to the more remote islands, all using amplitude modulation with double-sideband transmission. All music channels used audio-frequency transmission, on screened pairs or on the phantoms of carrier cables. Since only one television transmitter was in operation, only local television cable circuits were required.

Multi-metering, enabling multi-unit fee calls to be completed automatically, was in restricted use, as was operator trunk dialling on single links.

THE WAR YEARS

Development during the War years was, by normal standards, unbalanced. Service requirements involved great expansion of the trunk network and the number of circuits of over 25 miles increased from 6,800 in 1939 (all in public service) to 17,000 in 1945. Despite the provision of 9,300 defence circuits, however, the number in public service increased slowly throughout the War. For long circuits, advantage was taken of the lower cost of provision by carrier and coaxial cables, so that, by the end of the War, the trunk network was largely on a carrier basis. Operator trunk dialling was extended to cover 62 routes, including those with the heaviest traffic in the country.

Submarine cables to the Continent were cut in 1940, but techniques for their maximum exploitation were pursued on inter-island links. These techniques were put to good use in systems which were prepared in readiness for the assault on Europe in 1944. In the event, many circuits were provided in this way, the first cable into the Normandy Beach-head being laid and in service three days after D-day. Some of these cables were the first to use polythene as a dielectric, this proving superior to gutta mixtures which were in short supply.

Just prior to the War, development had been commenced on intermediate amplifying units for submarine cables, with particular thought to thin many coaxial cables in the shallow waters around the British Isles. These "repeaters" were to rest on the sea bed and be powered from the shore over the cable itself. Progress under wartime conditions was slow and it was not possible to obtain components of the superlative quality now considered essential. Nevertheless, repeaters were completed and the first one laid in the Irish Sea in 1943—the first in a working cable, despite an earlier start in America.

In telegraphy provision was also primarily for defence. The number of public channels increased from 1,800 in 1939 to 2,600 in 1945, but after 1939 there also grew up the Defence Teleprinter Network with manual switching. This reached a total of over 7,000 channels in 1944. Manual switching was introduced in the public telegraph service at a few points in 1944.

In radio, development under the stimulus of war was rapid and pulse techniques, initially developed for radar, were adapted to short-distance telephony. Whereas, in 1939, radio circuits were operated almost exclusively with amplitude modulation, by 1945 frequency-modulation and pulse-modulation were in

use, thus paving the way for post-War development. The success of the Army "No. 10 Set," which provided eight telephone circuits by time-division multiplex at 5,000 Mc/s, was outstanding. Development of these pulse techniques also laid the foundations of digital computing and electronic switching.

POST-WAR DEVELOPMENTS

The position facing the Post Office after the War was formidable: to make up the leeway and extend exchanges to meet the back log and pent-up demand. The vast wartime provision of defence circuits was transferred to the public service and gave a good start in this field, though a considerable amount of reconditioning was necessary. The position in respect of exchange plant and subscribers' lines was far less happy and the post-War story has been a continual struggle to meet demands for service. Technical means and manufacturing capacity have been available in plenty but rigid Treasury control of capital investment and expenditure—relaxed from time to time, only to be reimposed as economic difficulties recur—has resulted in a waiting list of a quarter of a million twelve years after the War, the peak number having been over half a million in 1950.

In America, the post-War policy of meeting such demands by any available means led to interesting new cable developments using plastics to replace lead, which was in short supply. In Great Britain developments in this direction have been real but more conservative.

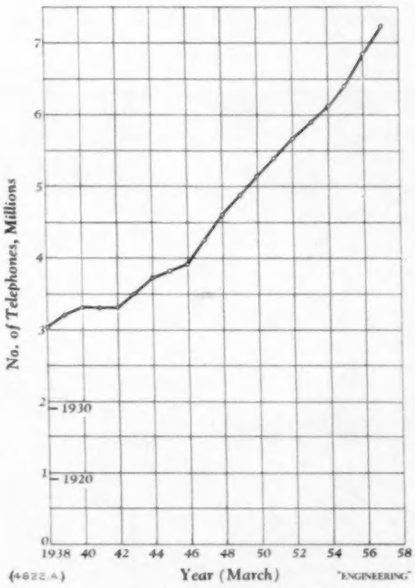

Fig. 1 Growth of telephones installed in the United Kingdom.

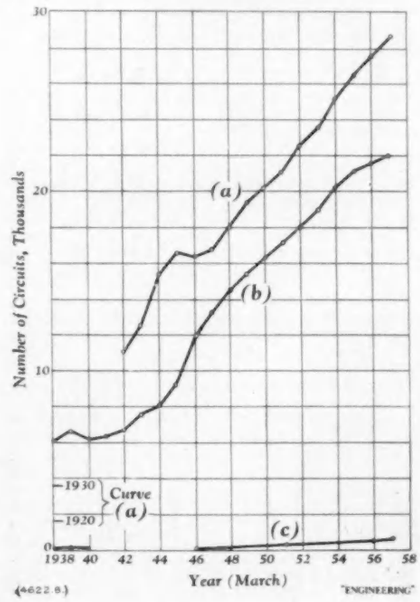

Fig. 2 (left) Growth of telephone circuits of over 25 miles in length. Curve (a) is the total inland; (b) public inland; and (c) international (cable).

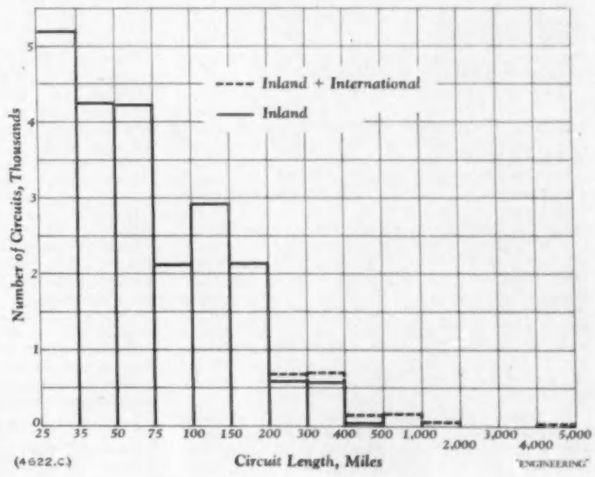
Inland + International
Inland
Number of Circuits, Thousands
25 35 50 75 100 150 200 300 400 500 1,000 2,000 3,000 4,000 5,000
Circuit Length, Miles
(4622.C)
"ENGINEERING"

Fig. 3 (right) Distribution by length of circuits of over 25 miles in length.

SUBSCRIBERS' LINES

Broadly speaking, technical improvements have been applied to giving service to more subscribers for a limited expenditure; standards, however, have not been relaxed. New telephone receivers have been designed, the latest having a balanced armature, greater sensitivity and a more uniform response. This and other improvements are being used to extend the permissible resistance limits of subscribers' lines and thereby enable the service area of an exchange to be extended or, alternatively, to give service on lighter cable pairs; wires only 0·012 in. in diameter are now in use experimentally. Flexibility of local networks was increased by the introduction, in 1946, of cabinets and pillars as two-stage interconnection points in subscribers' lines.

Shared service for residential subscribers, introduced on automatic exchanges during the war, has been greatly extended to make more efficient use of local cables. The average residential subscriber uses his telephone for less than ten minutes per day so that, even with two parties sharing, line occupancy is very low. It is not economic to provide independent ringing and metering for more than two parties and shared service tends to be unpopular. The solution would seem to be the use of subsidiary switching units as close as possible to a group of subscribers. Country Satellite Exchanges, long in use, must be connected to manual exchanges but new units, to be introduced shortly, are associated with automatic exchanges, of which they are essentially decentralised switching stages.

Attempts have been made to extend carrier telephony to subscribers' lines but no system cheap enough to effect savings in this country has been produced. In countries where rural subscriber density is much lower such schemes, using transistors, are in operation, sometimes with as many as ten parties connected to each carrier circuit with common metering and code ringing.

The growth of the number of telephones since 1939 is shown in Fig. 1. Although the present total is exceeded only in the United States, the density is still low, being 13·5 per 100 population and exceeded in the United States (33·7), Sweden (30·4), Hawaii (29·0), Canada (26·3), New Zealand (24·6), Switzerland (24·3), Denmark (20·1), Australia (17·8), Norway (17·2), Iceland (17·1) and Alaska (16·8). The number of calls is about 78 local and 7 trunk per capita per annum, or 580 local and 50 trunk per telephone—about one fifth, per capita, of that for the United States, Canada and Sweden.

TELEPHONE EXCHANGES

The process of mechanisation has continued so that nearly 80 per cent. of the telephones are now automatic; of nearly 6,000 exchanges only 20 per cent. are manual. All automatic exchanges still employ mechanical switches, but considerable progress has been made experimentally in electronic switching. There are many ways in which electronic devices can replace mechanical switches, but the economic design of an electronic exchange must take advantage of the particular capabilities of electronic devices, e.g., the very high speed of operation of valves and transistors and the simplicity of storing signals on modern magnetic materials.

The type of electronic exchange being developed here exploits the sharing principle to a much greater extent than mechanical exchanges. Up to 100 circuits are multiplexed on common-highway connections within the exchange. We have seen that, on long-distance circuits, this is effected by frequency-division multiplex which is insensitive to the phase characteristics of the system. Within an exchange, phase-distortion can be kept low and time-division multiplex proves much more economical. For speech having a maximum frequency of 4 kc/s, all the essential information can be determined by sampling 8,000 times per second or more. The equipment is capable of selecting, and transmitting without significant distortion, pulses one microsecond in length; it is thus possible to accommodate over 100 channels at the above sampling rate. Other exchange requirements are the storage of instructions for the disposal of messages—library information—and of control information, e.g., signalling. For these purposes, several types of storage devices are available; mercury delay lines, magnetostriction delay lines and rotating magnetic drums have been used in experimental units.

To obtain early experience in electronic switching, six all-electronic directors were installed in London in 1952; their function is to receive the called subscriber's number, translate the first three (code) digits into routing digits on the basis of stored information, and to re-transmit the number; this application has been entirely successful. The first all-electronic exchange is due for completion in 1960 and will be a product of collaboration between the Post Office, which has pioneered the work, and the principal British contractors. Much remains to be done, but it is expected that electronic switching will ultimately prove cheaper, more compact and more reliable than mechanical switching at some, if not all, stages. Whether the ultimate exchange will be entirely electronic or mixed electronic and mechanical is uncertain.

INLAND TRUNK CIRCUITS

At the end of the War it was clear that all inland circuits over about 25 miles should be on a carrier basis. Multi-pair cables with 24 channels per pair appeared to be suited to shorter distances than coaxial cables with many hundred of channels per pair, but the line of demarcation was not clear. A feature of international co-operation in the immediate post-War era was a change in the activity of the International Consultative Committee on Telephony (CCIF, now CCITT). Before the War this committee had been mainly concerned with the co-ordination of existing practices in the various countries so that satisfactory international connections could be made. After the War it attempted to decide, by advance agreement, how development should proceed. As Britain was the only European country with a modern communication network, British practices were accepted in large measure. Among other matters, the CCITT recommended the pattern to be adopted for coaxial cables of $\frac{3}{4}$-in. diameter, which were to provide either 960 telephone circuits or one television channel in the range 60-4,000 kc/s. Strictly speaking, CCITT recommendations apply only to international circuits, but they usually set the pattern for internal circuits also; the system was therefore developed and expanded to meet the recommendations. The 960 individual channels are assembled in groups of twelve in the range 60–108 kc/s, which assembly is also employed for multi-pair carrier cables. Five groups are then assembled as a supergroup in the range 312–552 kc/s and sixteen such supergroups make up the coaxial

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system. The processes involved are, effectively, translation of bands of frequencies to different points in the frequency spectrum by amplitude modulation and filtering; within limits they can be carried out freely and with little impairment of the basic signals. A music channel can be provided within any 12-channel group, as an alternative to two or three telephone channels.

Interconnection between systems can be effected at high frequencies, either as groups in the range 60–108 kc/s or as supergroups 312–552 kc/s.

Television links are provided by coaxial cable and also by radio. Extension of the frequency band of coaxial cables to 12 Mc/s, now planned by halving the present standard repeater spacing of six miles, will lead to greatly increased facilities as also will proposed new radio-relay systems.

Whereas British post-War development has, like American, been primarily on coaxial cables, a number of European countries have favoured multi-pair cables. Our own exploitation of such cables has not been taken beyond 24 channels per pair but on the Continent, where closer limits were imposed on cable construction, more circuits have been provided in this way. Recently, extension to 60 channels has been contemplated here, and the replacement of paper lappings on the wire by foam polythene or by polystyrene lappings is now leading to 120-channel working on the Continent. In America only 12 channels are provided on each pair.

The economy of modern carrier systems is such that it is now possible to provide long-distance circuits more cheaply than before the War; moreover, this trend continues, despite rising prices, as techniques are developed. The growth in the number of circuits over 25 miles in length is shown in Fig. 2 and the present distribution, on a basis of length, in Fig. 3.

INTERNATIONAL CIRCUITS

Since the War there has been a great increase in the number of circuits to Europe provided, economically, over a number of routes by the use of submerged repeaters; the Post Office has pioneered work in this field. Regularly spaced and powered from one or both ends, such repeaters permit of circuit provision over submarine cables on much the same basis as on land. The main system in use provides 60 circuits on a single cable; 120-circuit systems will be laid shortly. To ensure long life for submerged repeaters requires components and workmanship of much higher standard than those usual on the best land-based equipment; this need increases as the inaccessibility of repeaters and cost of replacement increase. The longest Continental route now in operation is between Scotland and Norway (300 nautical miles); a 500 nautical mile system to Sweden, involving about 27 repeaters, is planned for 1960.

Far bolder in conception than the Continental systems is the transatlantic system, completed in 1956. This, a joint British, American and Canadian venture, provides 36 circuits to New York and Montreal, both over 4,000 miles distant; one circuit extended to Scandinavia is over 5,000 miles in length. These circuits link two enormous telephone populations, the 56 million telephones in the United States alone being double the number in the whole of Europe. The circuits have negligible loss in a transit connection and are constructed to high standards; the attenuation distortion is only half the limit permitted by the CCITT for circuits only 1,600 miles in length. The opening of cable service has more than doubled the traffic to New York and more than trebled that to Montreal. A similar system will be laid in 1959 with the European terminal in Brittany and a 60-circuit system is due for completion between London and Montreal in 1961.

Two types of system are involved in these projects. The first is American and involves uni-directional amplifiers which are flexible enough to pass round the 7 ft. diameter laying gear of a cable ship and can therefore be laid as part of a continuous laying operation; two cables are required for the two directions. The second is British, developed from shallow-water experience and providing 60 circuits on a single cable. It uses rigid repeaters which require special handling gear on the ship. The Atlantic crossing involves a length of about 2,000 nautical miles and ocean depths of about 2½ miles (where the water pressure is 3 tons per sq. in.). In the present link, and in that planned for 1959, the Atlantic is spanned by the American system (51 repeaters in each cable) while the British system is used in the shallower waters between Newfoundland and Nova Scotia. For the 1961 Atlantic crossing, only British repeaters will be used, over 90 being required.

All other global circuits remain on a radio—mainly short-wave—basis and over 70 such circuits now link Great Britain with 40 other countries. Techniques have been refined and four telephone circuits can now be provided on each link. Elaborate aerial systems are in use and little more can be done to overcome the vagaries of short-wave propagation.

Hopes of improved long-distance reception have been raised by the exploitation of scatter techniques. By using many kilowatts of transmitted power and antennae of very large dimensions, scatter in the troposphere can be utilised to give broad-band transmission at distances of some hundreds of miles at frequencies of hundreds of megacycles/sec. Broad-band telephony or television are practicable within the limitations of the system and the advantages of direct transmission over such distances are obvious. The cost of the systems is high, however, and fading effects are not easily eliminated; moreover, the frequencies required are in the range used by television and the interference effects of the high power required could be very serious. A non-optical link of this type between the Orkneys and Norway (225 miles) has been in operation since 1954.

Somewhat similar effects can be obtained over considerably greater distances using ionospheric scatter at frequencies about 40 Mc/s, but in this case only narrow-band transmission is possible.

RADIO IN THE INTERNAL NETWORK

There are now a number of VHF inter-island links, each providing 12 or 24 telephone circuits by frequency-division multiplex; the stabilising effect of frequency-modulation enables these circuits to be freely connected as part of the internal system.

Development of radio-relay systems has now brought this form of transmission into competition with lines for long inland circuits. The main application so far, in this country, has been in the provision of television links. The first London to Birmingham link was operated at a frequency of 900 Mc/s with four intermediate stations; later links have been at 2,000 and 4,000 Mc/s with relay stations spaced at about 30 miles. The systems employ frequency modulation and the requirements of television are met more readily than those of multi-channel telephony. In America such systems now provide one-half of all long-distance telephone, programme and television circuits, the principal system having six broad transmission bands in each direction, each suitable for either television or more than 600 telephone channels. The relay spacing is about 30 miles and the type of antenna employed is suitable for additional systems at 2,000, 6,000 and 11,000 Mc/s. The 6,000 Mc/s system, due for service in 1959, will provide either 11,000 telephone circuits or 12 television and 2,500 telephone circuits, with a potential increase to 13,000 telephone circuits or their equivalent; this is provision on lavish scale indeed. The 11,000 Mc/s system operates over relatively short distances.

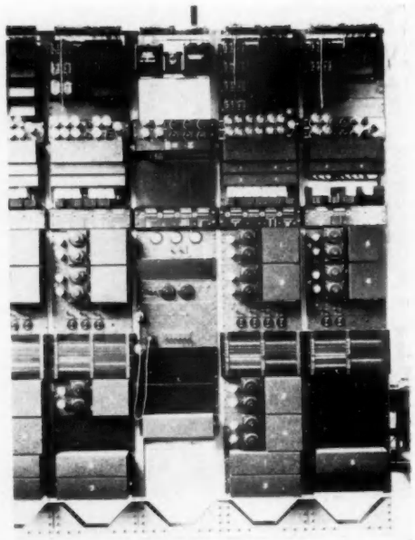

Fig. 4

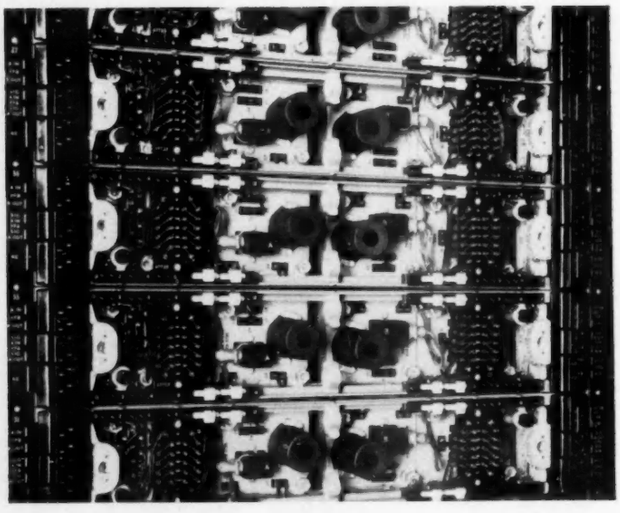

Fig. 5

Figs. 4 and 5 Audio-frequency repeaters. Fig. 4 shows early equipment for four circuits on each bay (1930) while Fig. 5 shows present-day equipment which mounts 12 times as many amplifiers in the same space.

The first 4,000 Mc/s system for telephony in this country has recently been completed in the North of Scotland, being the first to employ travelling-wave-tube amplifiers; a backbone system from London to Edinburgh will follow. In all these radio-relay systems, the same types of channel, group and supergroup terminal equipments are used as for cables, with which high-frequency inter-connections are permissible; only the transmission medium differs.

Before the War it would have appeared to be a safe prediction that the future of long-distance telephony resided in cables on land and by radio over the oceans; to-day we might well be tempted to predict just the reverse! The enormous capacity of micro-wave radio-relay systems seems just what is wanted for heavy integrated duties; there are still, however, residual technical difficulties.

The techniques of pulse modulation and time-division multiplex, so successful in wartime, have not yet found a place in the network except, as noted, in electronic switching.

TELEGRAPHY

On inland and Continental routes, telegraph transmission is completely integrated with telephony, the standard provision on modern telephone circuits being 24 channels. Two types of service are provided by this means, the normal public service and telex, both employing teleprinters. Inland public circuits are switched automatically at some 20 centres, thus eliminating all re-transmission; the corresponding Continental service still operates on a point-to-point basis although automatic switching is under discussion.

Telex is growing at a considerable rate. It is still operated manually but a national numbering scheme exists as a preliminary to automatic switching, which is due to commence in 1958. By 1961, a telex subscriber will be able to set up, without assistance, any connection, either national or to such countries overseas as are linked by cable and suitably equipped. Telex services to America, South Africa and many other overseas countries are available by radio and service to Canada was recently opened on the trans-atlantic cable.

In 1947, the services and inland networks of Cable and Wireless were taken over by the various Commonwealth Governments and the residue of the company, including its vast network of submarine telegraph cables, became a British Government-owned company. Operation of the services in this country were taken over by the Post Office in 1950 and integration proceeds. The telegraph office at Electra House is the largest in the world, employing some 3,500 staff, and plans for mechanisation are under consideration. Somewhat similar traffic problems, though of much

smaller magnitude, occur at other points. Airport authorities and commercial units handling considerable telegraphic traffic are finding it desirable to speed up either simple switching or more complicated processes of handling and re-transmission. The simplest arrangements for the latter involve receiving the message on punched tape and passing torn-off tape to an appropriate transmitter. This gives a local record but is cumbersome when the required outlet is not free and is not very well adapted to multi-addressed traffic, which is common. Electronic switching and storage are therefore coming to the forefront and techniques are being borrowed from both electronic telephone exchange and computer development. Unlike the telephone exchange it is necessary to store, not only library and control information, but also the messages themselves, until such time as they are re-transmitted; the grade of service must be 100 per cent. in this art. The types of digital stores favoured are the magnetic drum and ferrite cores having bi-stable magnetic states.

The submarine telegraph cables of the Cable and Wireless network, like those of the other cable companies, still operate on a d.c. basis though it has been possible, in some cases, to increase the speed of operation by inserting one submerged repeater, with a gain of up to 80 dB, near the edge of the continental shelf at the receiving end. This provides gain before the noise, inevitably associated with telegraph cables in shallow water, is picked up. The operating speed can be increased by about three times in this way, but the facilities for duplex operation are lost; the net gain is thus about 50 per cent. Very few of the telegraph cables are in sufficiently good condition to permit repeaters being fitted at regular intervals. There is some small scope for the operation of multi-channel voice-frequency telegraphy in this way but the real future of the submarine-telegraph lies in integration with telephony on repeatered coaxial cables. Telegraph circuits already operate to Canada on the transatlantic telephone cable and, by adopting synchronous working over the cable section instead of start-stop together with other refinements, it will be possible to double the number of channels normally provided on a telephone circuit.

Radio-telegraph services now commonly use error-correcting codes. By adding redundancy to the signals (the normal 5-unit binary code is increased to 7 units, of which four must be marks and three spaces) the presence of nearly all errors can be detected and repeats called for automatically.

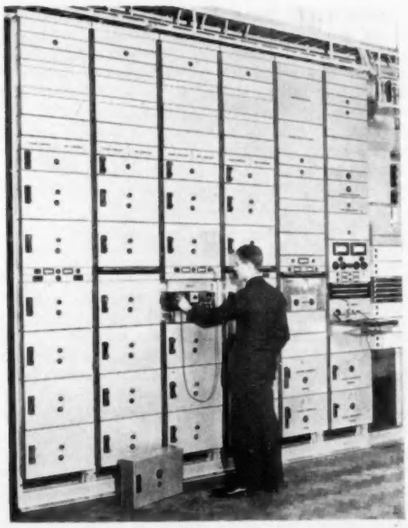

Fig. 6 In 1950 a 12-circuit group of carrier terminal equipment occupied two bay-sides.

TRUNK OPERATING

To speed the setting up of connections and reduce costs, operator trunk dialling over single links had been introduced in 1939 and all major centres, involving about 9,500 trunk circuits, are now equipped for this purpose. The current programme of trunk mechanisation, to be completed about 1960, will enable an operator to dial any inland subscriber directly. Multi-metering now covers up to four-unit fees.

The next objective is to give subscribers themselves full access to the trunk system so that they can, without assistance, make any national call. This demands that each subscriber must be identifiable by the same number from any point, which requires up to ten digits. As a start, it is planned to give all subscribers on Bristol main exchange trunk access to some two million subscribers at centres with direct connections to Bristol. An essential item of equipment is a register-translator to store the dialled digits, route the call appropriately and determine the charge, based on both time and distance; some of these functions are the same as those of a director and similar techniques are being followed, including experimental electronic inits. In America, experimental automatic ticketing and accounting schemes are in operation as an alternative to automatic metering.

Operator dialling is in use on certain Continental routes and will be applied extensively in 1959; there are also plans for a similar service to America on the transatlantic cable.

INFORMATION SERVICES

The success of the speaking clock service has been phenomenal and other information services have been studied and planned. The weather forecast service is now in operation at a number of major centres and special services such as test-match scores have been introduced on occasions with considerable success.

The meteorological service itself requires a large network of telegraph and telephone circuits which, with their equipment are rented from the Post Office. The International Meterological Teleprinter Network covers Western Europe as well as this country. Transmission of weather charts has opened a new field for facsimile telegraphy; line and radio telephone circuits are used for the simultaneous transmission of the Weatherfax system and 10-channel voice-frequency telegraphy.

EQUIPMENT

In such a paper as this it is only possible to draw a picture of development with very broad sweeps of the pen; to attempt to describe equipment is clearly impossible, yet it is the availability of new components, circuitry and equipment practices which has done much to make progress possible and to reduce costs, notably in line transmission and radio. As an example, in 1930, repeaters for four audio-frequency circuits filled both sides of an equipment bay (Fig. 4); to-day, twelve times as many amplifiers, as well as all associated line equipment are so mounted (Fig. 5). Again, the carrier terminal equipment provided prior to 1951 occupied two bay-sides per 12-circuit group (Fig. 6); to-day two groups are accommodated on one bay-side (Fig. 7) and the performance is also improved. In a new design, not yet in service, three groups and their associated signalling equipment occupy one bay-side (Fig. 8) and further size reductions are under discussion. With present-day circuit requirements, equipment of the old dimensions would have created impossible accommodation problems, just as manual switching would have created impossible staffing problems.

All new low-frequency equipment is, where possible, being transistorised and the latest design of line amplifier requires only one-tenth of the power of that shown in Fig. 5. This policy will extend to higher frequency equipment as suitable transistors become available.

Printed circuits are used in certain applications; they are available for subscribers' instruments and may be standardised, subject to satisfactory field trials.

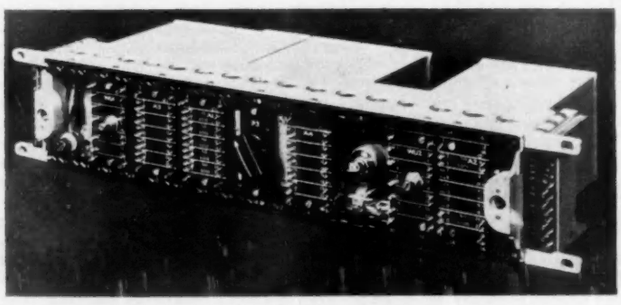

Fig. 7 (left) Since 1951, two 12-circuit groups of terminal equipment occupied only one bay-side —and the performance was improved.

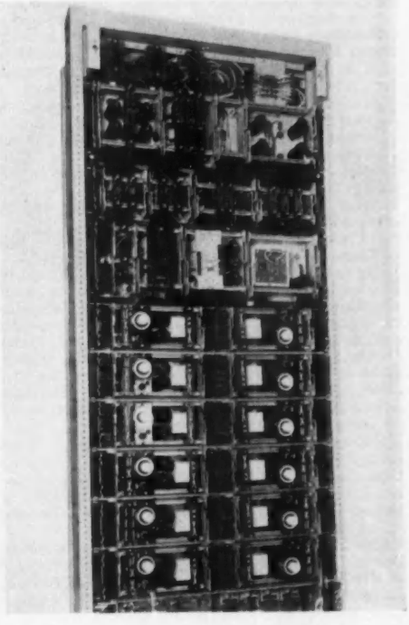

Fig. 8 (right) In the near future new design will allow terminal equipment for three 12-circuit groups to be accommodated on one bay-side.

THE FUTURE

Progress in electronics has been so rapid in recent years that it is difficult to see far into the future. In certain respects, such as subscriber trunk dialling, where decisions have already been taken, the pattern of development is reasonably clear. This also applies to the main trunk network of coaxial cables and radio-relay links which will be capable of carrying every form of communication service, including colour television. New forms of service will probably include data transmission in digital form; the need for this arises from plans to set up centralised computer and data-processing services. Transmission could be either at about 50 bits per sec. over telegraph channels or at higher speeds—perhaps 750 bits/sec.—over telephone circuits. The need for high accuracy of data transmission can be met by suitable error-correcting codes and these should make it possible to give service over switched 4-wire connections as well as over private wires.

Means will almost certainly be found to employ plant more economically. In any transmission system there is an optimum balance between the cost of the link itself and of the terminal equipment used to exploit it. When cables 100 miles or so in length were used for the transmission of audio-frequencies only, nearly all expenditure was on the link itself; to-day, the pendulum has overswung and the cost of channel equipment is excessive in relation to the cost of the line; we ought to spend less on each channel at the terminals and, if necessary, more per channel on the line. On very long submarine cables the position is just the reverse and we must find means of spending more at the terminals in order to get better usage of the line.

The solution of the short-line problem lies, possibly, in more generous frequency spacing, leading to cheaper filters, and in a closer integration of signalling and transmission equipment. In pulse-code modulation (PCM) we have means for quantising speech and transmitting it in digital form. This requires a phase-compensated transmission system and a substantial increase in bandwith but is much less sensitive to interference and therefore permits of greater spacing between amplifiers or relay stations. If terminal equipment for time-division multiplex can be made much cheaper than conventional carrier equipment, PCM might well be valuable, in some applications.

Means for increased utilisation of very long cables include less wasteful (and more expensive) filtration and band-compression systems. A number of schemes for extracting essential information from speech and eliminating redundancies have been explored. There is a great deal of room for economy

Continuing Research and Development

between the 3,100 c/s now usually allowed for speech transmission and about 40 c/s theoretically necessary to identify some 40 different speech sounds. All the systems tried so far, however, result in speech which, even if reasonably intelligible, lacks naturalness and is generally unacceptable for social purposes.

For the economic transmission of television over long distances, we must again spend money at the terminals to eliminate signal redundancies—a problem which is receiving attention but which is not yet properly solved. A somewhat crude television service has been demonstrated in America over normal telephone circuits; this achieves economy by transmitting only very slow movements, a restriction which may be acceptable for a personal service.

A novel device, now being developed in America for use on very long telephone circuits, takes advantage of the fact that the occupancy of a speech channel, when nominally busy, is less than 50 per cent. —a circuit is never occupied in both directions at the same time. By the application of electronic-switching techniques it is possible to seize a unidirectional channel only when speaking and by this means the number of conversations carried can, on a reasonably large group of circuits, exceed the number of circuits by a factor of about 2·5. The equipment is expensive and, on land, it only appears to show a saving at distances over about 1,500 miles; this distance will tend to increase as the cost of the circuits themselves continues to decrease. The system is likely, therefore, to have its main application on transoceanic cables.

The success of the transatlantic telephone cable is already leading to further ventures and we can envisage a new global network of telephone cables to replace the existing telegraph cables and absorb their traffic. The traffic handled by the twenty telegraph cables which now span the Atlantic, could be carried comfortably on a single telephone circuit.

Some of the techniques of submarine cable telephony are almost certain to be reflected in land systems; repeaters buried in the ground or in manholes would avoid the delays and expense associated with the provision of surface repeater stations and the number of power-feeding points could be greatly reduced. The advent of transistorised high-frequency repeaters should help materially in this sense.

The use of wave guides for long-distance transmission over land is, in the long run, a likely possibility, especially circular guides employing the H_{01} mode, in which attenuation decreases as frequency increases. A wave guide of this type would be capable of circuit provision in what, even to-day, would be considered fantastic numbers and would obviate the fading and interference which still mar even the best radio-relay systems. Whether semiconductor devices will ever be devised to amplify these very high line frequencies, perhaps 50,000 Mc/s, remains to be seen, but units for 10,000 Mc/s are stated to be under development.

Revolutionary changes in the local telephone networks could come with electronic exchanges if the shared-highway principle within the exchange could be extended beyond it to detached sub-units, or even to the subscriber. There are severe difficulties in transmitting short pulses without that distortion which would lead to mutual interference but it would be rash to predict that this will prove impracticable for dense telephone areas. The ruggedness of transistors and their low power requirements may make it practicable to increase the complexity of the equipment at a subscriber's premises and to energise it from the exchange; for example, a high-quality microphone would be possible. A choice of broadcast programmes by carrier transmission over subscribers' telephone lines is already technically possible and could well be exploited.

" Hands-free " telephone service is now increasingly in demand and, for business uses in particularly, is likely to be an irresistible requirement for the future. Reasonably suitable equipment exists for good telephone connections, but the technical difficulties of using loud-speaking equipment on mediocre circuits are considerable and it is unlikely that satisfactory service could be given on all calls. Equipment exists to make suitable announcements to a caller during the subscriber's absence and also recording equipment to accept messages; such equipments are not yet in general use here.

The possibilities of new services and methods are boundless and we can be certain of only one thing—that the place of telecommunication in the social and business life of the peoples of all countries, as well as for defence purposes, will increase immensely as the years proceed.

Acknowledgment.—The permission of the Engineer-in-Chief of the Post Office, to make use of the information contained in this paper, is gratefully acknowledged.

Book Reviews

IMPROVING MANUAL SKILL

The Training of Workers Within the Factory. Report prepared by the National Institute of Industrial Psychology. Project No. 179. *The European Productivity Agency of the Organisation for European Economic Co-operation, 2 Rue André-Pascal, Paris, 16e, France* (300 francs); and *H.M. Stationery Office, Kingsway, London, W.C.*2. (6*s*.).

The European Productivity Agency—the branch of the Organisation for European Economic Co-operation responsible for stimulating productivity—recently sponsored a survey of current practice in the systematic training of operatives within the factory. The survey was carried out by appropriate bodies in Austria, Belgium, France, Holland, Italy, Western Germany and the United Kingdom. In the case of the last-mentioned country, the National Institute of Industrial Psychology not only carried out the nation-wide investigation, but was also charged with the task of co-ordinating the whole inquiry and reporting on it.

The present booklet summarises, briefly and lucidly, the seven national reports, and the result is a masterly and very readable condensation. An introduction outlines the reasons for, and the procedure of, the investigations, and there follow brief reviews of the factors in the industrial situation of each country which were important, including the level of industrialisation, the state of education, the classification of work, and the labour situation. Sections are then provided on each country's arrangements for education and training for skilled work, and the factors which influenced the development of systematic training are traced.

No precise definition of " systematic " training was propounded, but the survey considered only situations where training was guided by a definite programme and carried out by someone specifically allotted to the task. Even so, difficulty was experienced in each of the countries in finding sufficient examples in certain industries, but a summary table is provided which shows the industrial class and size of the 700 establishments which were visited, nearly one-third of them being situated in the United Kingdom. The organisation of training in these establishments is considered next; but their individual requirements had led to such a wide variety of arrangements that no specific conclusions could be deduced from the examples, except in so far as it was considered better to start with a simple organisation.

Instructional technique was, in the opinion of the investigators, one of the weakest features of the training schemes considered. Visual and other aids were examined, but it was felt that the chief need was for greater skill in the art of instruction. Some interesting examples of operator training outside the factory are quoted from Austria, Belgium, France and Scotland; and it is noted that, although joint schemes for operator training in a locality have often been discussed in England, none seems to have come to fruition.

The results and benefits of systematic training are also very briefly cited, though the investigators had great difficulty in obtaining anything more than opinions, which were almost always favourable. Reductions in learning times, amounting to a half, or more, of those previously required are quoted for seven operations, and improvements in quality for two others. Reduction in cost was not usually available, but " in two instances in the United Kingdom, savings of £90 and £60 per trainee were reported."

The conclusions drawn from the survey are inevitably very general, but the need for the better training of instructors, more encouragements to learn, the keeping of appropriate records, and the adequate analysis of the job, are rightly emphasised. These suggestions, coupled with the national reports, should serve to stimulate a greater appreciation of the importance of, and need for, systematic operator training. They also pose a number of practical questions: in particular, by what means small and medium-sized companies can obtain access to the experience on which to make the right decisions in organising systematic training. Neither surveys nor research can be fully fruitful unless such problems of application can be surmounted.

PRESENT AND FUTURE OF A POLYMER

Polythene. The Technology and Uses of Ethylene Polymers. Edited by A. RENFREW and PHILLIP MORGAN. *Published for " British Plastics " by Iliffe and Sons Limited, Dorset House, Stamford-street, London, S.E.*1. (126*s*.)

This is a work of major importance on account of its content and because it illustrates the way in which new materials are nowadays discovered and developed. The work, which is divided into three sections, namely, manufacture and properties, processing techniques, and applications and prospects, has been edited by a director of a division of a leading industrial company, and by the editor of a technical journal. Such an association has allowed the recruiting of 38 specialists from the United Kingdom and the United States to contribute the 32 chapters of the book, giving all the known relevant facts concerning polythene. Inherent difficulties always arise in that overlapping and even contradiction may occur when encyclopaedic works are undertaken. It is proper to say that these faults are noticeably absent, but it must be added that the level of writing is somewhat uneven with some of the later chapters failing to maintain the high standard established in the earlier sections.

The book opens with an excellent account of the history of polythene and chapters on raw materials and manufacturing processes are followed by others dealing in great detail with the chemical and physical properties of polythene. It is here that the reviewer finds an outstanding illustration of the modern approach to the understanding of a material. At an increasing rate it has become the practice to study the constitution of basic materials such as coal, metals and textile fibres and here the research associations, with industry, have made major contributions to the application of these studies. Yet polymers, such as polyethylene, are almost as well understood during their development period as these other materials are after centuries of use and generations of study. The examination of the atomic, as well as the crystal structure, does much to explain the chemical, physical and electrical properties in the case of polythene as of other plastics.

Of greater importance is the way in which required properties are shown as being possible of achievement and, with polythene, we are already enjoying the advantage of modified forms. It is inappropriate to attempt here a description of the changes in properties which have been achieved, although the use of irradiation to impose the qualities of thermo-setting rather than thermoplastic material is of great interest. This is a pointer to what is possible if the user assists in developments by bringing his needs to the notice of the prime producers. During the period in which the book has been in preparation, new high-density types of polythene have been synthesised and the authors have diligently paid regard even to current work. In fact, the bibliographies given at the end of the chapters

are commendably comprehensive and up to date, including, as they do, references to many patents.

Readers of this journal may be assumed to be most concerned with the properties of polythene as a constructional material and to be already familiar with the great contribution made by the outstanding dielectric properties as used in the manufacture of high-frequency cables. The lay public has ample evidence of the appearance of this new material in the production of familiar articles in daily use, and some encouragement can be found in the attention being paid to the possibilities of polythene as a constructional material in the wider sense. Here film used as a moisture barrier in concrete structures and for confining agricultural sprays, are applications which could and should, with advantage, be extended.

The final chapters of the work deal with the future outlook of polythene in the United Kingdom and the United States. It is clear that there is a great faith in the probability of the demand for even increased quantities, but one would have looked for a more venturesome forecast of developing uses outside those of the small individual component.

Engineers are presented with a book which is as authoritative as it is instructive and there should now be no lack of knowledge of this valuable polythene. The editors, authors and publishers have done a fine job and it remains for the technologist to use this material to its fullest advantage.

★ ★ ★

NEW BOOKS

Arcs in Inert Atmospheres and Vacuum. Edited by W. E. KUHN. *John Wiley and Sons Incorporated*, 440 *Fourth-avenue, New York 16, N.Y., U.S.A.* (7.50 *dols.*); and *Messrs. Chapman and Hall Limited*, 37 *Essex-street, London, W.C.2.* (60*s.*)

This volume consists of papers presented at a symposium "The Electric Arc in Inert Atmospheres and Vacuum" held at the spring meeting of the Electrochemical Society, Incorporated, at San Francisco in April, 1956. The contents are divided into four sections: the historical development of controlled atmosphere arcs; arc melting fundamentals; design and operation of arc melting furnaces; chemical applications of arcs. There are 14 papers in all, each having a list of references. Most of the contributors are engaged in work in American industry, but a paper on German developments in the vacuum arc melting of titanium and zirconium is included.

The Detection and Measurement of Infra-Red Radiation. By R. A. SMITH, F. E. JONES and R. P. CHASMAR. *Clarendon Press: Oxford University Press, Amen House, Warwick-square, London, E.C.4.* (70*s.*)

The purpose of the book is to provide for advanced students and research workers a comprehensive account of the developments that have taken place in recent years on the techniques used for the detection and measurement of infra-red radiation. After a short introduction on the historical development of infra-red techniques the book deals with the properties of thermal detectors such as thermo-piles and bolometers and discusses their limitations. An account is then given of modern photo-conductive detectors that use the lead salts PbS, PbTe, PbSe. A full discussion is given of the random fluctuations that limit the sensitivity of all forms of detectors and a comparison is made between the various types. An account is given of the development of infra-red spectrometers, and of the properties of optical materials and devices as used in the infra-red. The book also deals with electronic techniques as used in conjunction with detectors and discusses the transmission of infra-red radiation through the atmosphere.

The Hypercircle in Mathematical Physics. By J. L. SYNGE. *Cambridge University Press, Bentley House*, 200 *Euston-road, London, N.W.1.* (70*s.*)

This book describes a technique for the approximate solution of certain boundary value problems of mathematical physics. The technique involves concepts of function-space. No special knowledge beyond the calculus is required of the reader, as the concepts are developed from first principles. Illustrative numerical examples are worked out in detail, with special emphasis on the torsion problem. The author has tried to avoid the rather bleak axiomatics that repel mathematical physicists and engineers for whom the book is intended and for whom function-space will remain a means to an end and not an end in itself. In the last part of the book, in the treatment of vibration problems, the familiar positive-definite metric of function-space is abandoned in favour of an indefinite metric, like the Minkowkian metric of space-time.

Industrial Electronics Circuits. By R. KRETZMANN. *Cleaver Hume Press Limited*, 31 *Wright's-lane, Kensington, London, W.8.* (35*s.*)

The book is a sequel to *Industrial Electronics Handbook* and the two form a continuous whole; references are made in this work to various sections of its companion. The book is one of the Philips' Technical Library series, and many of the circuits include Philips' components. There are six sections: photo-electrically controlled apparatus; counting circuits; stabilising circuits; contact and control devices; oscillator and amplifier circuits; rectifier and motor control circuits. The volume is intended for industrial engineers and also for technicians engaged in the development of electronic equipment. Nearly 200 circuits are included, and photographs are used to illustrate the design of apparatus.

Chemical Process Economics in Practice. Edited by J. JAMES HUR. *Reinhold Publishing Corporation*, 430 *Park-avenue, New York* 22, *N.Y., U.S.A.* (4 *dols.*); and *Messrs. Chapman and Hall Limited*, 37 *Essex-street, London, W.C.2.* (32*s.*)

Seven papers presented at the "Experience in Industry" Symposium held in Philadelphia, Pennsylvania, in April, 1956, are reproduced in this volume. The symposium was sponsored jointly by the Philadelphia Wilmington Section of the American Institute of Chemical Engineers and the School of Chemical Engineering of the University of Pennsylvania. The subjects covered include the principles of accounting; the elements that constitute the investment for a new processing plant; the allocation of indirect investments or costs to the integrated processing plant or its products; the direct costs of materials, labour, etc.; pricing the chemical product; the economic analysis of a chemical processing project; and financing the capital needs of new plant.

Linear Programming. An Explanation of the Simplex Algorithm. By DAKOTA ULRICH GREENWALD. *The Ronald Press Company*, 15 *East 26th-street, New York* 10, *N.Y., U.S.A.* (3 *dols.*)

The book explains the simplex algorithm as used in hand-computed solutions of linear programming problems. Early in the text an example is given of the manner in which the most economical schedule for three machine tools would be drawn up. Later more complex problems are considered. The book is intended for people with some mathematical background—engineers and also students in other fields. Among the topics considered are formulation of the product-mix problem and the problem of distribution costs. A short chapter on further studies ends the book and some references concerning the development of particular aspects of linear programming are included.

Physical Optics. By R. A. HOUSTOUN. *Blackie and Son Limited*, 17 *Stanhope-street, Glasgow, C.4.* (40*s.*)

This book is intended for students who have reached the intermediate science standard in physics and who are proceeding further with the study of light. The author has had two classes of student in mind: those studying light for higher examinations in physics, and those specialising in chemistry, biology or engineering, or engaged in industry, who require some knowledge of the subject. The latter have now become a larger class than the former. He has therefore adopted the standpoint of physical optics; used description, graphical construction, and intuition wherever possible; and has avoided elaborate mathematics. A list of references is included for further study.

On the Shelf

By Frank H. Smith

In my reference on August 23, page 243, to the projected guide to library sources in the West-Midlands area I implied that Aslib members had not been considered. Brian Staples has kindly written to tell me that in this I am in error. All such special sources were taken into consideration but many of them had to be rejected as they have no stock worthy of inclusion. Mr. Staples's letter to the Press aimed at reaching those sources which belong neither to the Library Association nor to Aslib. I rather doubt, though, if there is any large collection (which, presumably, would be in charge of an intelligent and far-sighted custodian) that considers itself so self-sufficient that it need not belong to Aslib or to the L.A. This does, however, highlight one little point about membership of Aslib. There are some instances in which the attendant privileges are regrettably one-way. A quite large firm (a hypothetical one of course) could quite easily pay a yearly fee to 4 Palace Gate and, in return, obtain a first-rate library service without having the expense of building up a decent collection of books itself. Aslib's Information Service becomes larger and more efficient year by year and it is quite easy for a lazy or incompetent librarian or information officer to shirk his responsibilities in this matter. On the other hand, most librarians take such pride in their work that only in the very last resource will they try Aslib.

A good example of co-operation between a librarian and an architect is contained in a paper issued by the South African Council for Scientific and Industrial Research, entitled: "C.S.I.R. Library and Information Division: The New Building," by Hazel Mews, Head of the C.S.I.R. Library and Information Division, Pretoria. The paper originally appeared in *S. A. Libraries* for April, 1957, but is available as a reprint (presumably from the author). My first sentence in this paragraph stems from one in the paper: "From the very beginning there was the closest co-operation between the architect and the librarian and all the warnings in the professional Press about the neglect of the librarian by the architect were in this case proved to be unfounded."

On September 6, page 307, I referred to the work of the Smoke Abatement Society and I have just seen what is, I presume, a continuation of a bibliography on the subject. The title is *Publications of the Community Air Pollution Programme*, and it is a list of papers (in ABC order of author) that have appeared in various publications in roughly the past two years. Further information is obtainable from Robert A. Taft, Librarian, Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati 26, Ohio, U.S.A.

Whenever I receive a secondhand bookseller's catalogue with a good selection of aeronautical material, I apply an "acid test." I look for an item by M. J. B. Davy on Henson and Stringfellow and almost invariably it is quoted at some fancy price. It is, of course, quite a handsome book and was the classic on these two pioneers until Pritchard's paper to the Royal Aeronautical Society. Davy was published by H.M.S.O. at 5*s.* and has only recently gone out of print. These remarks are prompted by a catalogue which I have just seen which asks 45*s.* for a secondhand copy!

This whole business of used books is most extraordinary and exciting. I have before me two catalogues from dealers in both of which appears copies of *Chambers Cyclopaedia*. Both must have a curiosity value only, since they are eighteenth century and one would have thought, therefore, that the older would be the more valuable. Yet the two-volume version of 1738 is offered by one dealer at 5 guineas and the four-volume edition of 1779-1786 costs £18, according to another. Nevertheless, second-hand lists can be bargain-mines, particularly if yours is a subject that is so recondite that its titles convey nothing to the uninitiated. For instance, I have just obtained Southwell's *Relaxation Methods in Engineering Science* for 18*s.*, and very pleased about it I am too.

Design

DATA ON HUMAN PERFORMANCE FOR ENGINEERING DESIGNERS

Concluded from page 347, September 13

By K. F. H. Murrell, M.A., F.R.P.S.

LIGHTING AND COLOUR

The evidence for or against the existence of visual fatigue is conflicting as also is the evidence relating lighting level to output,[39] nevertheless, it seems indisputable that ease of seeing, especially with fine work, is dependent on well planned lighting and the output can be adversely affected by poor lighting.

Definitions

Luminous flux—F.	1 lumen	= luminous flux produced in 1 steradian by a uniform point source of 1 standard candle.
Brightness—B. ..	1 ft. lambert	= brightness of a perfectly diffusing surface emitting 1 lumen per sq. ft.
Illumination—E..	1 lumen per sq. ft.	(Also known as foot candle.)
Reflection Factor—R.	The percentage of incident flux reflected by a surface.	

There are three main factors which influence visual efficiency and comfort :—

(*a*) the amount of light on the task;
(*b*) contrast between task and surroundings;
(*c*) glare.

The Amount of Light for the Task

The amount of light required for efficient performance of a task is influenced by four factors which are interdependent:—

(*a*) the size of the object;
(*b*) the time allowed for seeing;
(*c*) the contrast between the object and its immediate background;
(*d*) the brightness.

The designer is likely to have control over the brightness, which is a function of lighting, and partial control over time of seeing and contrast. The brightness required cannot be determined without first establishing the other three parameters.

The Size of the Object.—Visual acuity (or the resolving power of the eye) depends not only on the size of the stimulus but also upon its intensity and is greatest in the foveal region. There are three slightly different processes involved in acuity. First, the ability to see two objects as separates, that is the gap between two objects; this is often measured by use of the landolt ring —a circle with a gap of known width. Secondly, vernier acuity, the ability to discriminate a discontinuity in a line. Thirdly, the ability to see a line. The approximate ratio of the three is 24 : 2 : 1. It is usual to express the limits of acuity in terms of the visual angle. Under the most favourable conditions the minimum angle of separation between two objects which can be resolved is as low as 24 sec. of arc.

Visual acuity diminishes with age so that an older person will need more light to see small objects than a younger person. The accommodation of the eye (ability to focus) also diminishes with age, from about 8 cm. at age 16 years to 100 cm. at age 60 years, so that the older person can less easily increase acuity by holding a small object nearer to the eyes. With contrast constant, acuity increases approximately with the logarithm of brightness, and with brightness constant it increases with contrast. So that for a small object, ease of seeing can be increased by manipulating both the contrast and the brightness.

For practical purposes the size of objects may be divided into five categories:

Category	Example
I.	Fine wires about 0·001 in. or smaller.
II.	Fine wires about 0·002 in.; fine scribed lines.
III.	Lines on slide rules or micrometers.
IV.	Sewing cotton, print about 6 point.
V.	Print about 12 point.

Strictly speaking, sizes should be expressed as visual angle but in this form they are not very easy to use and the above examples are based on a normal viewing distance of about 18 in.

The Time Allowed for Seeing.—Acuity decreases as the logarithm of speed of movement increases or decreases with time of seeing, if very short. The shorter the time allowed for seeing the lower the effective acuity. It follows, therefore, that the longest time practicable should be allowed for seeing very small objects; if they are moving, movement should preferably be intermittent to allow for inspection.

Contrast.—Acuity increases with contrast, which depends on the relative amounts of incident light reflected by the two surfaces under consideration. It is defined as

$$\frac{R_b - R_d}{R_b} \times 100 = C$$

where R_b, R_d = reflection factors of the brighter and darker objects respectively.

This relationship is expressed graphically in Fig. 33.

It is important not to confuse reflection factor and brightness. They are related to the illumination:

$$B = \frac{E \times R}{100}$$

R is constant for any given material so that B varies with E.

In measuring R, care must be taken not to confuse units. Thus if E is measured by means of a footcandle meter, B must also be measured in lumens per sq. ft., which is not easy. B can more easily be measured with an instrument such as an S.E.I. photometer. If this is used alone it is necessary to estimate E by measuring the brightness of a surface of known R. Clean white plaster has R of about 95 and this can be standardised by measuring its reflectance when E is known. (Pure magnesium carbonate is better than plaster if it can be obtained.)

For example, using the photometer, a sheet of grey paper gives a reading of 40 ft.lbt. and the white plaster, under the same light, 90 ft.lbt. so that the brightness of a perfect reflecting surface of R = 100 would be 94·7 ft.lbt. (or E = 94·7 lm. per sq. ft.). From this the reflectivity of the grey paper is easily obtained.

$$R = \frac{40}{94{\cdot}7} \times 100 = 42$$

For many practical purposes R can be obtained from a table such as that given below:

White plaster	About 95
Good quality white paper, white tiles	About 85
White plastic or porcelain enamel	About 75
Medium quality white paper	,,
Bright brass	,,
Aluminium	,,
Bright copper	About 65
White cloth	,,
Newsprint	About 55
Concrete	,,
Plain white wood	About 45
Dull brass	About 35
Dull copper	,,
Bright steel	About 25
Cast or galvanised iron	,,
Black cloth, if not matt	About 15
Printers ink of good quality	,,
Matt black paper	About 5

The Brightness.—The brightness will depend, as has already been stated, on the illumination and the reflectance of the material constituting the task. Recommended illumination levels have steadily increased over the past 50 years and appear to depend to an extent on what is technically and economically practicable. The recommended levels of current practice are well above threshold requirements for seeing. Visual efficiency rapidly improves immediately above threshold, but the rate of improvement tends to flatten out and it has to be decided at what point standards are fixed.[39, 41]

In suggesting levels of lighting, therefore, it has been necessary to bear in mind levels recommended by the British I.E.S. (1949) and the American I.E.S. (1942). In general the Americans recommend levels for similar tasks which are about twice the British. It will be seen that there is no finality in this matter and that the suggestions given below are an indication of the influence of the various factors already discussed on the light required for a task and not a statement of absolute level. In general it is unlikely that any harm will be done by increasing lighting levels above those suggested. A suitable relationship between brightness and contrast for the five size categories is given in Fig. 34.

As an example of how this is used, consider the task of bending a "cat's whisker" of 0·0015 in. bright copper wire. Assume that this task is seen in silhouette against a white background which has R = 70. Bright copper has R = 65 but as directional lighting will cause one side to be shadowed a value of perhaps R = 50 should be used. Therefore, using Fig. 33, C is 28. Entering Fig. 34 at C = 28 and curve II, a brightness of 250 will be required on the background, and this will call for illumination of 350 lumen per sq. ft. Should there be no shadow then up to 530 lumen per sq. ft. would be required.

Or consider the task of working on cloth with self coloured thread. If the cloth be white its reflectance may be about 65, that of the thread may be about R = 55 (allowing for shadow). Therefore using curve IV the illumination required will be about 115 lumens per sq. ft. It is arguable that a task involving black thread on black cloth of R = 15 would require the same brightness (75 ft.lbt.) and an illumination of 500 lumens per sq. ft. But it could equally be argued that the effect of shadow on black thread is less than on white thread and that there is little difference between the reflectances of the cloth and the thread. Under these circumstances 860 lumens per sq. ft. might be required.

It will have been noticed that in these examples two alternative levels have been arrived at according to the assumptions made. It would seem that the level to be used might fall somewhere between the two, using the highest level which is economically possible.

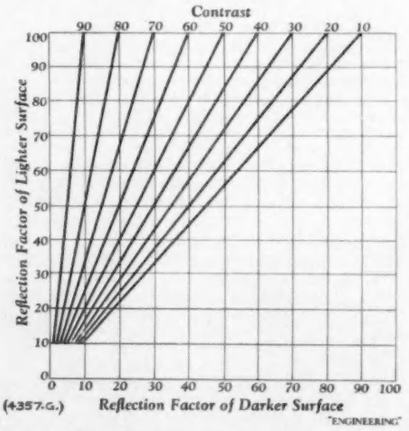
Contrast
90 80 70 60 50 40 30 20 10
Reflection Factor of Lighter Surface
100 90 80 70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100
Reflection Factor of Darker Surface
(4357-G.)
"ENGINEERING"

Fig. 33 The variation of reflection factor with contrast.

Contrast Between Task and Surroundings.—The contrast between the task area and the surroundings can not only influence the visual comfort of the operator but can also assist in holding his attention to the job. Unfortunately the two are conflicting and any system adopted must be a compromise.

For visual comfort the immediate surroundings of a task with high reflectance should be rather darker than the task itself and the general surroundings rather darker still. The brightness of the task should not differ by more than 3 times from that of the immediate surroundings, which in turn should not differ by more than 3 times from the distant surroundings.

Using a control panel as an example—if the enamelled dials have a reflection factor of 80, the panel should have a reflectance of not less than 27, and the surrounding room not less than 10. These are limits and in practice reflectances higher than these would be used.

The use of contrast to aid concentration depends on the phototropic effect—that is the tendency of the eye to move to the brightest part of the visual field. The effect is met in the extreme when the eyes are attracted to the headlights of an oncoming car and phototropism is widely used in advertising. The phototropic effect is used by making the surroundings darker than the task by more than 3 : 1 and the darker the surroundings the greater will be the effect, but the greater also will be the visual discomfort. Thus it will be necessary to decide just what degree of isolation from surroundings is demanded by the task and to adjust the contrast accordingly. In general mental tasks, such as reading test instruments, will be more likely to benefit from the phototropic effect than repetitive machine-paced tasks which require little or no deep concentration. Conversely, areas in the surroundings which are brighter than the task will tend to attract the eye away. If they become too bright they will be glaring and uncomfortable.

Control over the surrounding contrast can be achieved both by balancing the local and general lighting and by the use of colour. Usually, both must be considered together.

Glare

The eye can adapt itself to a wide range of brightnesses. When, however, contrasting brightnesses pass beyond the limits of the adaptation mechanism, discomfort and strain will be experienced or a diminished ability to see, especially fine detail, will result.

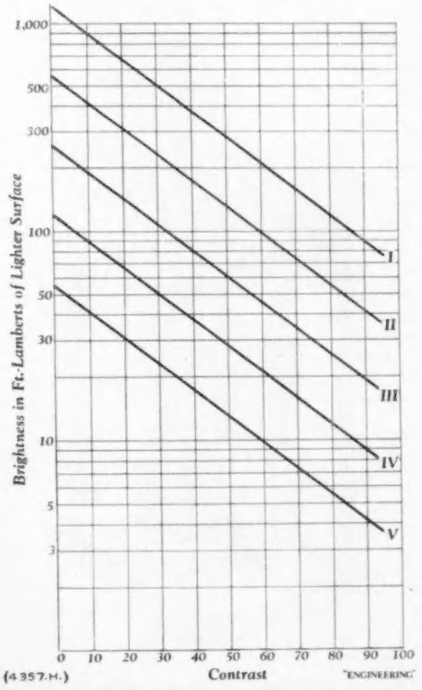

Fig. 34 The variation between brightness and contrast for the five size categories.

Discomfort Glare.—A light source which is more than about 100 times brighter than its local surround may produce discomfort glare, but the extent of the effect will depend on the size and brightness of the light source as well as the size and brightness of the surround, and the angle by which the glare source is separated from the line of view. The surround should be appreciably larger than the source. For instance, a light source of about 1 sq. ft. in area hung from a 10 ft. ceiling should have a limit of 2 candles per sq. in. Bare fluorescent tubes are above this limit. Solid reflectors mounted on a low ceiling will produce glare either from the lamp itself or from the inner white surface seen against the dark background. Additionally, an effect of lowering the ceiling will be produced. About 25 per cent. of the light of a fitting should usually be thrown upward.

Hopkinson[37, 38] has developed an empirical relationship between these factors:

$$\Sigma \frac{B_s^{1\cdot6}\ \omega^{0\cdot8}}{B_b^{1\cdot6}} = G$$

where

B_b = surround brightness (foot lamberts)
B_s = source brightness (foot lamberts)
ω = source area (steradians)
G = glare constants

He suggests that glare constants up to 35 are acceptable, between 35 and 150 are distracting and above 150 are uncomfortable.

Two common sources of glare are windows and unscreened luminairs. Glare from windows may be reduced by painting internal and external reveals white; by fitting venetian blinds, absorbing glass or translucent curtains; by painting adjoining walls a lighter shade than side and opposite walls; by arranging machines so that operators do not face the windows.

Glare from artificial light may be prevented by cutting off direct light below an angle of 45 deg. above eye level; by lightening the surround; by allowing a proportion of the light to be thrown upwards or whitening the ceiling; by enlarging the area of brightness, for instance, by using diffusing panels.

Disability Glare.—Excessive light entering the eye from objects in the field of view other than the task can cause disability glare, that is, a reduction in the ability to see; other things being equal, the greater the amount of light entering the eye from the glare source the greater the disability. Disability glare will reduce the size threshold and contrast, and so should be particularly avoided with work involving fine detail and low contrast. A glare source of 5 lumens per sq. ft. at 5 deg. above the line of vision reduces visibility by about the same amount as it would be reduced by substituting 1 lumen per sq. ft. lighting system for a 100 lumen per sq. ft. system. Glare can be removed by displacing the light source from the field of view; merely substituting a pearl lamp for a clear one or enlarging the light source will have little effect.

Disability glare can also result from having too high a contrast between the task and its immediate surround. For instance, very fine scribed lines on a small dark plate may require 400 lumens per sq. ft. If this plate is on a white bench top, the latter may be as much as eight times brighter than the task and some disability may result. If the white bench is also shiny the brightness may be many times higher and serious disability may result.

Planning for Efficient Visual Performance

The variety of parameters which may influence efficient vision on a particular job is such that ideally every job should be studied separately and the best conditions established. Usually, the general lighting in a factory is planned before the machinery is installed. It may be perfectly adequate for general work but quite inadequate for some tasks. Machines may have been rearranged in a new pattern and light which was perfectly adequate may become inadequate and local lighting, when provided, may be left to the operator to adjust to what he thinks is most satisfactory. In any event, the provision of light fixtures is only one of the factors influencing good seeing. The following steps should therefore be taken.

Determine the contrast of the job and where necessary increase it as far as possible. Provide the lightest possible background to dark fine detail by painting jigs white or by the use of ceramic or enamel plates; use the darkest background for light objects and illuminate bright objects diffusely so that they reflect light. Use oblique light to bring up imperfections on a flat surface. Bring up fine scribed lines by placing a diffuse light so that it is reflected by the lines, but not by the plate on which they are scribed. Use coloured light complementary to the detail. Use back lighting to emphasise detail in transparent objects. Avoid direct or specular reflection which reduces the reflectivity of the background. Make use of shadow to darken such objects as a fine wire or to aid in fine positioning movements such as placing the point of a pencil on a sheet of paper; it is difficult to judge distance accurately with " shadowless " lighting.

Decide whether high concentration or comfort are required. The former will usually be called for in self-paced mental tasks in potentially distracting surroundings. If comfort is required avoid sharp contrasts between the task and the surroundings; beyond the range of the supplementary lighting (if any) this will usually be achieved by means of the colours used to paint the machinery and the walls.

Ensure that there are no sources of glare (natural or artificial) in the visual field—in particular pay attention to the ceiling against which light fittings may be seen, to windows and to fittings for supplementary lighting. Glare can often be prevented by changing the colour of the surroundings. Avoid reflections from bright objects, particularly when close to the task, for example, plated bezels on gauges.

Attention to these details on jobs already installed and when new processes are designed will assist in promoting visual comfort for the operatives and is likely to result in increased productivity. Those who wish to go deeper into the subject should study the literature, particularly Weston.[41]

Colour

As has already been mentioned the aim of a colour scheme in a factory should be to make seeing easier. It should also be used to emphasise potential hazards or danger points; to produce effects of atmosphere, cleanness and efficiency; for identification.

The use of colour to avoid sharp contrasts has been discussed above. In general, ceilings and walls adjacent to windows should have a reflection factor of not less than 55 per cent. Distracting features such as roof trusses should be light. Reflection factors of British Standard Colours are given in Table X.

TABLE X.—*Reflection Factors of Some British Standard Colours (after Weston[41])*

R.	
79—70	Pale cream, 52.
69—60	Deep cream, 53. Primrose, 54. Lemon, 55. Golden yellow, 56.
59—50	Light buff, 58.
49—40	Mid buff, 59. Eau de Nil, 16. Sky blue, 1. Silver grey, 28. French grey, 30. Old battleship grey, 31.
39—30	Sea green, 17. Salmon pink, 43. Deep buff, 60. Mid stone, 62. Orange, 57.
29—20	Turquoise blue, 2. Light brown, 10. Golden brown, 14. Quaker grey, 29.
19—10	Dark battleship grey, 32. Post office red, 38. Sage green, 19. Grass green, 18. Peacock blue, 3. Mid brown, 11.
9—0	Crimson, 40.

The inner surfaces of machine casings and undersides of overhanging parts should be kept light—this will help cleanliness as well as vision. Bright colours should be avoided on the body of a machine, quiet finishes of medium reflectance which harmonise rather than contrast with the surroundings are recommended. Vivid contrasts should be confined to critical situations such as gears, cutting edges, moving parts, levers

Continuing **Design**

or control buttons. Machine guards should be considered as part of the machine, but the danger area behind should be painted in a vivid colour.

Warm saturated colours (yellows, reds) give a sense of warmth and an advancing effect. Cool shades (blues, greens and greys) give a sense of coldness and recession. Thus a narrow working area can be made to appear wider by using a cool colour on the side walls and warm colour on the ends. Horizontal breaks, such as dadoes, tend to reduce apparent height, while having the upper wall and ceiling of the same colour will create a feeling of spaciousness. Pillars, and so on, which are a hazard should be in a warm contrasting colour.

Hot working areas or those with a southern aspect may be helped by a cold colour scheme and rooms with a northern aspect by a warm one.

It is said that warm colours, particularly red, are exciting and stimulating while cool colours are soothing.

The following colours have been recommended for identifying hazards:

Alert ..	Orange ..	Danger points on machinery, etc.
Attention ..	Yellow ..	Cranes, changes in floor level, etc.
Safety ..	Emerald ..	First aid equipment, safe areas, etc.

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PLANETARIUM FOR LONDON

The world's 32nd planetarium, comprising 29,000 parts, valued at nearly £100,000, has recently arrived in London. The operation of the planetarium, which is the first in the Commonwealth, was fully described by Dr. H. C. King in an article published in ENGINEERING on March 1 this year (vol. 183, page 258). The inventor, Professor Walther Bauersfeld, technical head of Zeiss, was earlier this year presented with the James Watt Gold Medal at a ceremony in London for his work on the planeterium. Planetaria are also being built by Zeiss for Caracas, Venezuela, and Johannesburg, South Africa. The British agent for Zeiss is Mr. A. H. Degenhardt, 47 Albemarle-street, London, W.1.

Son —

Stereophonic sound recording, besides entering the wide-screen cinema, plays an important rôle in Son et Lumière. For when light and sound are used to suggest the presence of invisible actors, much realism is gained by the apparent changing of position of the sound source. However, in stepping from the cinema to the garden the acoustic technique has encountered new problems.

In Fig. 1 a set of three Elipson delivery chambers is shown. They are made up of a reflector for all frequencies above 800 c/s, and a spherical reflex baffle tuned for frequencies below 800 c/s. The loudspeakers used have a minimum diameter of 30 cm. and the impedance of the moving coil is 5 ohms. An average power of 20 watts can be provided and peak powers of up to 50-60 watts are permissible. The loudspeaker membranes are given a special treatment to permit their use in the open.

Each loudspeaker chamber is fed by an amplifier that can furnish a power of 80 watts, with a level of distortion below 2 per cent. The amplifier pass-band is level to ± 1 dB. between 50 and 100,000 c/s.

The programme is recorded on magnetic tape. To avoid complications during rendering, and to make the rendering as automatic as possible, at least three sound channels are needed. Two of the channels use superimposed reading heads able to read a recording directly, and the third is inserted between the first two. Tape speeds of 38 or 19 cm. per sec. allow playing times of 30 or 60 minutes. The player is fitted with a double stereophonic head and a single running head. Pre-amplifiers are fitted that provide a pass band that is level to ± 1 dB. between 30 and 15,000 c/s (for the 38 cm. per sec. speed).

A typical sound-control room, that at the Château de Versailles, is shown in Fig. 2. The controls consist essentially of attenuators and double balances. The tape desk and its pre-amplifiers are situated in the control desk. To allow the operators at the desk to follow the programme, sound sources analogous to those outside are provided by loudspeakers mounted in the control room.

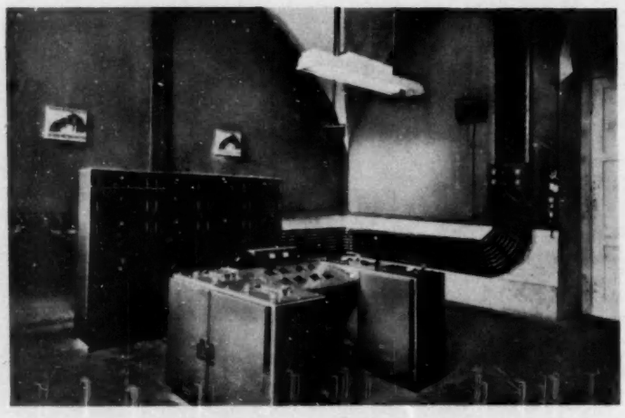


Fig. 1 (above) The loudspeakers that provide the sound are mounted in delivery chambers equipped with a reflector and a reflex spherical baffle.

Fig. 2 (left) The various loudspeakers around the control room at the Château de Versailles correspond to the groups of external speakers.

et Lumière

The light control is carried out with units similar to the one shown in Fig. 3. Each consists of operating levers, an eight-slide auto-transformer, and a protection panel. The levers, capable of rotation in either direction, may be individually connected in a direct or inverse direction on a main driving shaft. The levers embody adjustable stops by means of which all progressive modification of the lighting can be interrupted at a predetermined value. In addition, the controlling handwheels allow the operation of any number of circuits, or group of circuits, together. The auto-transformers are rated at 20 kW, 220 V.

At Greenwich

M. Paul Robert-Houdin, who introduced Son et Lumière at Chambord in 1952, was in charge of the recent production at Greenwich. The technique "using buildings as canvas, light as paint" was applied to the Queen's House, the Royal Naval College, and the National Maritime Museum. Words, music, colour and light were used to describe the history of the buildings, the narrative being dramatised by a succession of over 100 different lighting effects.

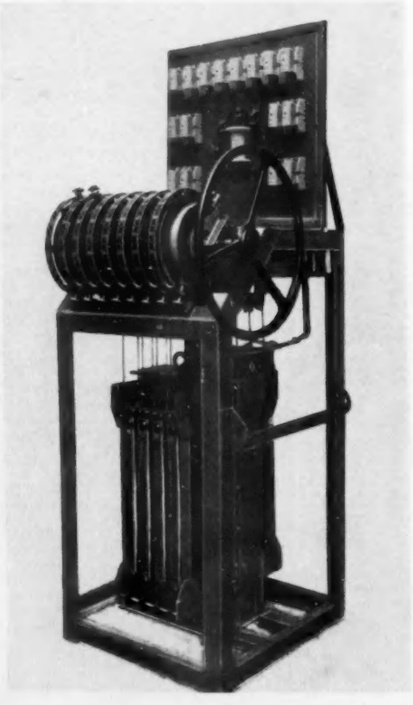
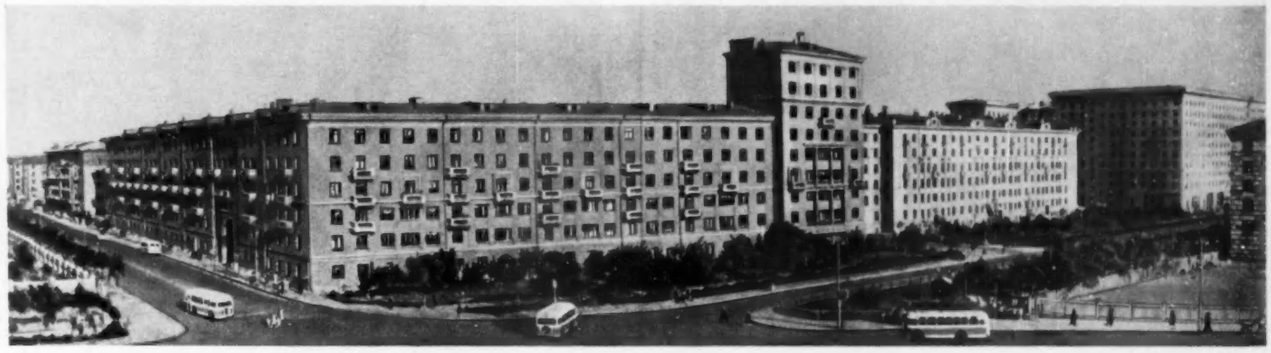


Fig. 3 An instrument such as this controls the lighting. The eight-slide auto-transformer can be seen under the main frame.

Production

HOW GOOD ARE SOVIET ENGINEERS?

The fourth article in our series on the quality of Soviet engineers considers the men, workshops and technical processes at the engineer's disposal. The series is being prepared by Mr. E. P. Ward, a Deputy Editor of ENGINEERING, *on the basis of a recent visit to the Soviet Union. Previous articles have discussed the Soviet engineer's environment and tastes, his sources of information, and his skill as a designer. A fifth article to be published next week will examine management methods, incentive systems, costing and welfare, and a final article will summarise the writer's conclusions.*



Apartment houses owned by the ZIL motor factory. Factories in the Soviet Union are often self-contained working communities

4—HOW THE SOVIET ENGINEER RUNS A FACTORY

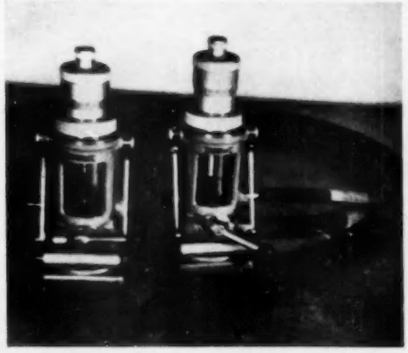
The basic unit of industry, whether Communist or Capitalist, is the factory, and it is on the efficient administration of this unit that technical success depends. Thus it is important in gauging the quality of Soviet engineers to study the context in which they work, to look at the factory as a separate self-contained organism, independent but for the supplies it needs and the services it renders. Indeed, many factories in the Soviet Union are complete colonies, with associated housing schemes, cinemas, theatres and even holiday resorts. In the following account, reference is made to labour, working hours, workshops and automation.

Labour

Economic theory recognises three factors of production: land, capital and labour. Labour, in this context, embraces the whole working population from poets and politicians to hewers of wood and housewives; but a more common usage implies at least an element of manual work, on the farm or in the workshop. Curiously enough, this distinction is also accepted in the Soviet Union, and the relationship between the men—and women—on the shop floor and the engineers who direct them is much the same as in this country. In the Communist Party office at the First State Ball Bearing Factory (GPZ), I saw a book entitled *The Working Class in the U.S.S.R.* When I drew attention to it and remarked that I understood Soviet society to be classless, I was informed that in the Soviet Union there were, in fact, three classes: peasants, workers and intellectuals; these did not represent a hierarchy but a team in which the intellectuals occupied a middle position, between workers and peasants. But, whatever terms are used, the temper of human relations in the Soviet factory struck me by its completely familar tone.

But there was one exception: had Valentina Petrovna, my interpreter, walked through an English factory, there would have been at least a few admiring whistles; in Russia there were none, scarcely a second glance. Possibly discipline is stricter or the men more courteous; perhaps the fact that men and women work side by side brings familiarity and complacency. The high proportion of female labour in Soviet workshops is impressive, serving almost to double the working population per unit consumer. At the ball-bearing factory roughly half the 10,000 employees are women, 52 per cent. at the Electrosila factory, and 30 per cent. at the ZIL automobile works. I saw women driving trolleybuses, operating forging presses, and skilfully manipulating red-hot billets with scissor tongs. My impression was that the women worked more persistently and conscientiously than the men, though perhaps with less imagination—but I failed to discover what percentage of accepted suggestions were proposed by women. However, a visitor can hardly judge working pace, since the mere presence of visitors and officials in a workshop may cause it to change.

Something has been said in earlier articles of the broad educational and training facilities available to workers, but it is equally important to discover their quality as craftsmen. Of the workers at the ball-bearing factory, only a very small proportion—cleaners and transport workers—are unqualified. Indeed, as has already been observed, unskilled labour is in such short supply, that an unskilled man may be offered living accommodation and command a higher wage than a qualified man. Often, as in this country, a senior craftsman will have a mate. The assistant will not, however, be an unskilled labourer, but a craftsman of lower standing. There are eight degrees of craft qualification, the eighth grade being the highest. A craftsman responsible for setting up machine tools at GPZ, where automatic tools are numerous, is normally of the seventh or eighth grade, representing some 10 or 15 per cent. of the workers, while his assistant or assistants will be of the fourth or fifth grade, or lower. Seventh and eighth grade men also provide 15 per cent. of the employees at the LMZ turbine factory, though at the Sverdlov machine-tool factory, the highest grade is the seventh, with the sixth and seventh grades forming 35 per cent. of the total.



Instrument for checking surface level over distances up to several metres. One tube carries the indicating fluid, while a second tube provides air compensation.

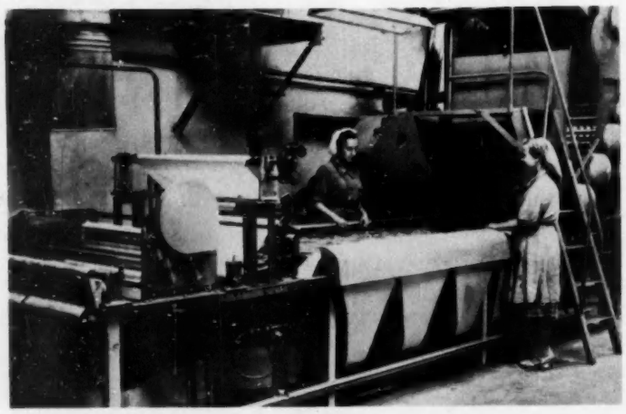
There is no system corresponding to our five-year apprenticeships. A boy on leaving school after the normal 10 years of education joins a trade union straight away and serves as a pupil craftsman for three or four months, though perhaps six months if he has attended school for less than 10 years. After this period he may become a low-grade machine-tool operator. In general, craftsmen of the seventh or eighth grade have received training at special technical schools. A boy would enter a primary technical school (F.Z.O., or school of factory training) after seven years of normal education, where he would study for two, three or four years before joining a factory.

The non-commissioned officers of Soviet industry are known as masters and are roughly equivalent to foremen. Masters are frequently diploma engineers, and engineering courses are arranged for those yet to qualify. At GPZ there were roughly 300 masters in a factory of 10,000, as against 400 or 450 engineers. It is of interest that a recent decree requires engineering graduates to begin their working career as masters. My guides were at great pains to emphasise that master did not correspond to the English meaning of the word—presumably a reference to our ironmasters of the past.

Intermediate between the workers on the shop floor and the engineers are the techniks (technicians), tracers and draughtsmen-designers, though there is, of course, considerable overlapping. To become a " middle technik " it is necessary to attend a course at evening school lasting four years. Often techniks are classed with engineers, though, where they are distinguished, engineers appear to outnumber them considerably; thus at the Sverdlov machine-tool plant there are 300 engineers and only 140 techniks, a curious proportion in view of a recent Western conclusion that ideally there should be four holders of Higher National Certificates to each engineering graduate. Of the 2,500 employees at the Sverdlov factory, 140 are draughtsmen and tracers; at Electrosila, where the total number of employees is 6,000, there are 700 draughtsmen, of which 60 per cent. are tracers. The LMZ turbine factory has two drawing offices (steam and hydraulic plant, respectively) and there are 500 engineers and techniks per office.

The normal retiring age for men is 60 and for

Continuing **Production**



Automatic machine for making mica insulation, designed and built at the Electrosila factory. The machine, which lifts the pieces of mica by vacuum, lays them between sheets of paper, and is said to give uniform thickness.

Beginning of an automatic flow line for the production of ball-bearings at the First State Bearing Factory, Moscow. The process includes heat treatment, checking and packing. A tidy shop is graced by an occasional aspidistra.

women 55, but for those engaged in heavy work the corresponding ages are 55 and 50; foundry work is considered an example of the latter. All may continue to work if they wish. These comparatively early ages must tend to offset the advantage in numbers afforded by the wide use of female labour. At one factory I was told that the number of absentees was between 2 and 3 per cent., a figure comparable to that in light and medium British industries.

The increasing demand for specialist knowledge means that in Russia, as elsewhere, the opportunities to rise from the shop floor to positions of prestige and authority become ever fewer. Even in America, where furnacemen and newsboys have long been known to carry executives' portfolios in their lunch tins, the likely man is now caught at an early age, educated and made a manager, whether he is the boss's son or not. A few of the old school still survive, but only serve to confirm the rule. Thus the chief engineer of one Soviet factory had worked there for 27 years, the first seven as a lathe operator. In that his case was quoted, I assumed it was exceptional.

Shifts

The present working week in the Soviet Union is 46 hours, comprising 8 hours for five days a week and 6 hours on Saturdays. However, a gradual reduction in working hours has been undertaken, and in two shops at ZIL, and in several shops at GPZ, a 7 hour day is already being worked. Not more than 2 hours overtime is permitted in any week, and pay is then at double rate.

Shift working as in other countries depends on the nature of the work. Thus at GPZ the automatic-lathe and heat-treatment shops are on two shifts, while flow-line, "one-off", instrument and repair shops, including sections of the three-shift shops, are on two-shift working. Automatic lines at ZIL, however, are operated on three shifts.

Workshops

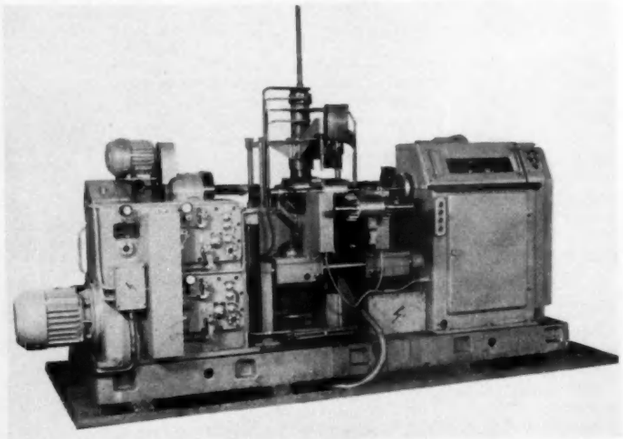
Of the factories I visited only two had been built since the revolution: ZIL in 1924 and GPZ under the first five-year plan in 1932. The earlier factories, two of which are some 100 years old, are similar to factories of like age elsewhere, with shops added in largely haphazard manner as the need arose. The other two have been carefully planned, and are therefore of more interest.

GPZ—the First State Ball Bearing Factory—is arranged about a straight spinal corridor 500 metres (1,600 ft.) long. The corridor is in fact double, an upper passageway for foot traffic and a lower tarmacadam way for vehicles. Workshops are distributed on both sides. Shops are clean and tidy, generally with wide lanes, though in some machine shops space between tools seems to be inadequate.

Methods of production and machines are generally up-to-date: high-frequency heating is in common use for applying cutting-tool tips; mechanisation and automation, which will be discussed in the next section, are playing an increasing part in production; high-cutting speeds are widely employed. Table I below has been taken from *Technical Progress in Machine-Tool Building* by A. Prokopovich of Enims (the machine-tool research institute); it gives cutting speeds for different kinds of machine tool in various countries. The table, which applies to 1955, is reproduced here without comment on its accuracy, bearing in mind that it is only intended as a rough guide—no materials (neither workpiece nor cutting tool) are specified; there is no indication as to depth of cut; and in this country at least, practice varies from factory to factory. The book appears to be written for engineers, though not specialists, and seems to be addressed to potential purchasers or planning authorities, rather than engineers in the machine-tool industry. The table also underlines the extent to which foreign tools are studied and compared.

High-speed cutting was also discussed during my visit to the Sverdlov machine-tool works, where Bartkevich, a leading Soviet specialist in this field, had worked. At the same factory, experiments to reduce "down-time" were in progress. Tungsten-carbide tipped tools were used but not ceramic tips, though I saw ceramic tools at the Tsnitmash heavy-industry research institute. The use of rolling techniques for producing threads and gears is also common practice. Heavy special-purpose machine tools have been developed for the production of Kaplan turbine blades at LMZ, as illustrated on page 443; and certain smaller machines are designed for easy transfer from place to place within a machine shop. A wide range of balancing machines are also made.

At the Hammer and Sickle metal factory, simultaneous broaching and heat treatment was being studied together with continuous casting. Typical of the plant in use was a UZTM four-



Automatic balancing machine, model 9720, *for electric-motor rotors ranging in weight from* 7 *to* 30 *kg. The residual unbalance is given as* 5 *to* 15 *gm. cm. and the cycle time* 1 *minute. The machine weighs* 4,000 *kg.*

TABLE I.—*Average Cutting Speeds for Machine Tools (Presumably Working on Mild Steel) in Various Countries; According to A. Prokopovich.*

	U.S.S.R.		U.S.A.		U.K.		W. Germany	
	Metres per min.	Ft. per min.	Metres per min.	Ft. per min.	Metres per min.	Ft. per min.	Metres per min.	Ft. per min.
Centre lathes	400–600	1,310–1,970	525	1,720	450	1,480	550	1,800
Boring machines	300–500	980–1,640	200–600	660–1,970	—	—	450	1,480
Drilling machines	80–100	260–330	92	300	—	—	160	520
Grinding machines	35	110	35	110	30	100	35	110
Milling machines	400–500	1,310–1,640	400–500	1,310–1,640	—	—	370–470	1,210–1,540
Gear-cutting machines	40–50	130–160	40–50	130–160	60–150	200–490	80–160	260–520
Planing machines	50–75	160–250	91·5	300	61	200	—	—
External broaching	14	50	14·7–80	50–260	—	—	—	—
Internal broaching	11	40	15–18	50–60	—	—	—	—

TABLE II.—*Improvements in Output Effected by Linking Machine Tools into Automatic Flow Lines in Four Soviet Plants*

Automatic line	Annual output per employee (items)		Annual output per productive worker (items)		Output per square metre of floor space		Cost per component (Roubles) (less reduction in materials costs)	
	Before installation of line	After	Before	After	Before	After	Before	After
Line for machining cylinder blocks of motor combine U5-M, at the factory "Hammer and Sickle"	1,000	11,700 (11·7 times)	1,125	28,400 (25·2 times)	67	87 (1·32 times)	43·87	28·95 (36 per cent.)
Two lines for machining cylinder blocks of Diesel tractor DT-65 at the Kharkov Tractor Factory	825	7,190 (8·7 times)	1,040	10,790 (10·3 times)	69	160 (2·3 times)	200	161·6 (24·5 per cent.)
Three lines for machining cylinder blocks of the automobile "Moskvich" at the Low Engine Capacity Motor Factory	3,354	7,270 (2·1 times)	3,963	10,900 (2·7 times)	110	208 (1·8 times)	8·07	6·78 (16 per cent.)
Four lines for machining cylinder blocks of the ZIL-150 at the Factory named I. A. Likhacheva	3,000	5,800 (1·9 times)	3,580	8,700 (2·4 times)	196	265 (1·3 times)	9·77	7·50 (23 per cent.)

high cold-rolling mill, 1,300 mm. wide, with a working roll 375 mm. and a back roll 1,100 mm. in diameter. Elsewhere I saw a spark-erosion machine designed for automatic copying and capable of producing a complete piston in hard metal in 40 to 45 minutes; tungsten dies could be made from copper patterns in some 10 or 15 minutes.

Metallising spray techniques have also been developed. At the LMZ turbine factory an electro-induction copy milling machine made by a Gorky factory (GZFS) was said to have reduced the time for producing a particular component from 1,500 to 100 hours; setting had previously been performed by hand. The same principle was used in machines made by the Sverdlov factory. Punched-card profile millers are also made, while photo-element, magnetic and punched paper tape techniques are under investigation.

At ZIL high-frequency heating was used for the welding of vehicle radiators. ZIL also had a single tool shop (employing two shifts of 800 men), served by a separate heat-treatment shop some 150 metres long. As in this country, factories frequently design and build special equipment for their own use. An illustration on page 442 shows an automatic machine for making mica insulation at the Electrosila factory in Leningrad.

Most factories have their own laboratories, often equipped with foreign instruments—I saw an Orcutt machine, for example; while high-accuracy jig borers, co-ordinate machines and other metrology apparatus were generally of Swiss manufacture. There were some five or six spectrographs at the Hammer and Sickle works, of which one (the ISP-28) was made at a Leningrad factory; but others were of German make. I also saw a Soviet-built electron microscope, and there were instruments at the Sverdlov plant made by the State Optical Factory. A simple but effective instrument devised by Enims for accurately gauging surface level is shown in an illustration on page 441; one connecting tube carries the indicating fluid and the other compensating air.

Methods of quality control range from simple devices for checking the size of bearing balls—to within 2 microns—by rolling them down sloping rails which gradually increase in separation (the balls fall into holes giving a final check on all-round diameter), to experimental apparatus using a photo-electric principle for investigating surface finish.

Automation

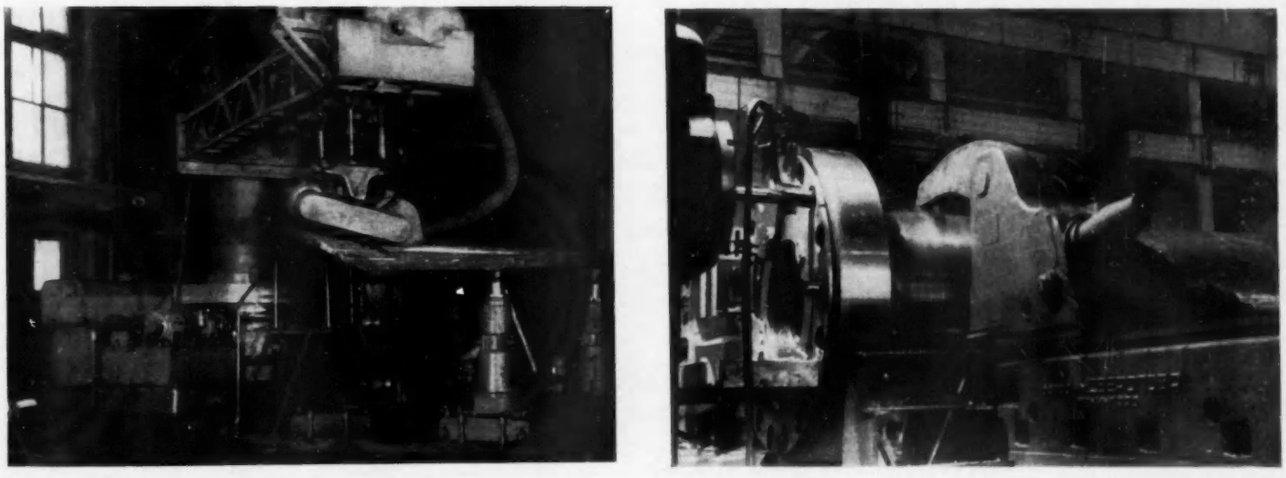
At Enims I was told that the shortage of unskilled labour in the Soviet Union made the introduction of automatic production techniques an absolute necessity. At GPZ, for example, two aims were regarded as paramount: firstly to minimise waste, and secondly to carry out a policy of gradual mechanisation. All kinds of machine tool are being checked at Enims for the possibility of programming, and complete flowlines are also being studied there—for machine tools as well as motor vehicles and tractors. A prototype line is often built at Enims before being installed at a factory.

Research on control techniques is being pursued vigorously, though not only for automatic production; thus at LMZ there is a special cybernetics group concerned with automatic regulation, electronic control and kindred subjects for turbines. At Enims it was emphasised that an automatic quality control or check line should be incorporated in a flow line wherever possible. Table II is taken from *Technical Progress in Machine-Tool Building* and shows improvements effected by the installation of four flow lines in the Soviet Union.

At the ball-bearing factory (GPZ), a total of 70 million bearings are produced a year (240,000 a day) ranging from 30 mm. to 1,800 mm. in diameter, some 1,000 types in all. Production is divided into two sections: mass production of particular items and also complete bearings where these are required in large numbers; and one-off or small-number production. The first of these sections is adapted to automatic methods, and there is, in fact, one shop which is completely automatic, with two flow lines, one for spherical and the other for conical bearings. No other bearing factory in the Soviet Union has as yet a fully automatic line. The general policy is to introduce completely automatic processes where possible, but otherwise to use old equipment and insert automatic sections as the opportunity arises, beginning with single tools.

A description of the GPZ automatic lines is as follows. Rough forgings for the bearing races enter the shop and are finished in a series of machines linked by conveyors. Balls initially produced from bar by a rolling process are also finished. High-frequency heating is used before hot working and items are subsequently weighed automatically. In between major sections of the automatic line are large through-flow storage chambers to compensate for fluctuations in speed, and gravity transfer is used wherever possible. The flow line includes a heat-treatment section where, after heating, the components are quenched in a bath at −70 deg. C., using freon refrigeration. On completion of the process, the items are cleaned and checked automatically, automatically assembled and checked again. Final cleaning, oiling and packing are also carried out automatically, the inner and outer races being packed separately. The output of one line is 180 bearings an hour. As a measure of the extent to which the lines are automatic, it should be noted that there are 35 setters for the two lines and 10 to 15 women responsible for size control.

Motor-vehicle production is well adapted to flow-line methods and at ZIL there are several scores of automatic lines. I saw the usual assembly line, in this case for ZIL-150 95 h.p. 4 ton trucks, and at strategic points overhead—and also in the controller's and despatcher's offices—there were display panels where red bulbs lit up to indicate points in the line where there was a stoppage. Each 3·5 to 3·8 minutes a truck would be completed, and subsequently receive a 40 minute test. The same factory makes refrigerators and bicycles, the production of the latter being at a rate of two a minute. ZIL has a modern foundry also operated on the flow-line principle, with a conveyor 20 km. long and a considerable range of automatic moulding machines. The operator responsible for pouring metal into moulds is himself carried on a moving belt.



For the production of Kaplan turbine blades and other large components, the LMZ factory, Leningrad, uses a variety of massive special-purpose equipment. On the left is shown an automatic profile grinding machine, and on the right a large horizontal machine for boring and reaming holes in large flanges.

Atomic Review

Reactors for the Sea

FISSION reactors form the present basis for exploiting nuclear power. Reactor comparisons have been made in this journal and elsewhere on several occasions, but as new materials are developed and new applications studied, it constantly becomes necessary to revise judgments as to the relative merits of different designs. The use of nuclear reactors for marine propulsion has recently captured wide interest, and it is important to determine which reactors are best suited to this purpose. The De Laval Memorial Lecture for 1957 arranged by Aktiebolaget de Laval's Ångturbin to commemorate the 75th anniversary of Gustav de Laval's application for his first turbine patent was presented by Dr. T. W. F. Brown of Pametrada. Speaking in Sweden on "The Propulsion of Ships by Steam Turbine Machinery," he devoted part of his paper to a consideration of nuclear propulsion for tankers. His approach was first to compare a number of reactor systems showing promise for marine propulsion, and then to present a more comprehensive comparison of three selected reactors used to propel a 60,000 ton deadweight tanker of 22,000 shaft horse-power. Dr. Brown's initial comparison of five reactor systems is itself interesting, since it takes into consideration recent reactor developments, and to some extent therefore, offers a revised assessment of nuclear reactor systems—but, of course, with particular reference to marine propulsion. This section of Dr. Brown's paper is abridged below. In a later article we hope to summarise Dr. Brown's detailed comparison of two reactors.

Reactor Variants

It appears that power reactors suitable for use in merchant ships are relatively few. The beryllium moderated gas-cooled reactor shows great promise, but requires considerable development, leaving the following possibilities: (1) graphite-moderated gas-cooled reactor with natural uranium or low enrichments; (2) pressurised-water moderated and cooled reactor with enriched fuel only; (3) boiling-water moderated and cooled reactor with enriched fuel only; (4) organic-liquid moderated and cooled reactor with enriched fuel only; and (5) heavy-water moderated gas-cooled reactor with natural uranium.

Enrichment

A question of considerable importance in connection with these possibilities is degree of fuel enrichment. Enrichment of uranium 235 by diffusion is extremely expensive since the power required to produce uranium 235 from natural uranium (in several thousand stages) is nearly equal to the power produced by the fissile material. Enrichments of the order of $2C_0$ ($2C_0$ represents twice the concentration of uranium 235 existing in natural uranium) by the addition of pure fissile material to natural uranium would be extravagant. Subsequent charges might, however, be enriched with plutonium extracted from spent reactor fuel.

A number of methods for separating the uranium isotopes are already familiar, but Professor William Goth, of Bonn University, claims that enrichments up to $2C_0$ are possible by the use of a centrifuge, with a reduction in power costs stated to be one-eighth to one-tenth of that for diffusion plants. For marine plants in particular, the use of low-enrichment fuels is of extreme importance, though plutonium enrichment may eventually ease the problem.

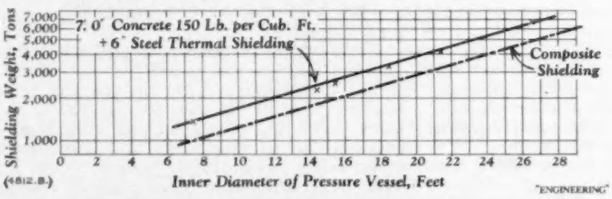


Fig. 1 Comparison by weight of conventional concrete shielding and composite shielding. The latter is likely to prove more suitable for marine propulsion applications, where weight is a major consideration.

Graphite-Moderated Reactor

With natural uranium, a graphite-moderated reactor requires for criticality a large investment of uranium, and the bulk and weight including shielding is such as to rule it out for marine propulsion in all but the largest ships. It has, however, enormous potentialities including the use of higher fuel temperatures; beryllium canning and ceramic fuel elements are possible developments. There are reports of a German concept using fuel elements in the shape of balls of uranium carbide mixed with moderator graphite. If successful, this system would allow steam temperatures up to 980 deg. F. (527 deg. C.). The size of gas-cooled graphite-moderated reactors decreases markedly when even fuel enrichment is used.

Shielding and Containment

All reactors introduce special problems in marine installations, owing to the need to save weight and space. The reactors form a complex source of radiation and the shield designer must approach the solution by a series of approximations. Gamma-rays are generated within the reactor and shield wherever neutrons are captured. The value of neutron and gamma currents leaving the core are of the order of 10^{13} per sq. cm. per sec. and attenuation of the order of 10^{10} is required to reduce this current to the maximum permissible level. For gamma-ray attenuation heavy elements are best whereas for neutrons hydrogenous materials are best.

In the design of shield for land-based reactors the saving in weight is seldom of importance, hence the almost exclusive use of concrete. Lead is a more effective shield for gamma-rays weight for weight than steel but steel is a much better structural material although hard gamma-rays are generated by neutron capture. The cheapest and most effective neutron shield is water. Concrete is cheap and effective in large thicknesses such as 7 ft. for land-based reactors, but it is considered essential to reduce weight and space on marine reactors and to employ laminated shields of lead, steel and water. Considerable research is required on such shields but the need is imperative to cut down shielding weight. Sufficient is known, however, to suggest that concrete shield weights can be reduced by a factor of 0·73 by such compound shield construction, including a certain amount of boral cladding. The shield weights have accordingly been calculated on a 6 in. steel thermal shield and 7 ft. of concrete (density 150 lb. per cub. ft.) and the weight then obtained by multiplying the resultant weight by 0·73. Although the weight reduction while significant is not as great as could be hoped, it is believed that the volume reduction is considerable. These weights are plotted in Fig. 1. The heat in the inner part of the shield would be removed by circulating sea water, and water in the outer part of the shield could be provided from the ballast pumping line. Cargo oil replaced by ballast when discharged might be considered for future shielding, but not in the early installations. Composite shielding consisting of concentric rings of steel plate, particularly in the outer diameter of the shielding, would represent very

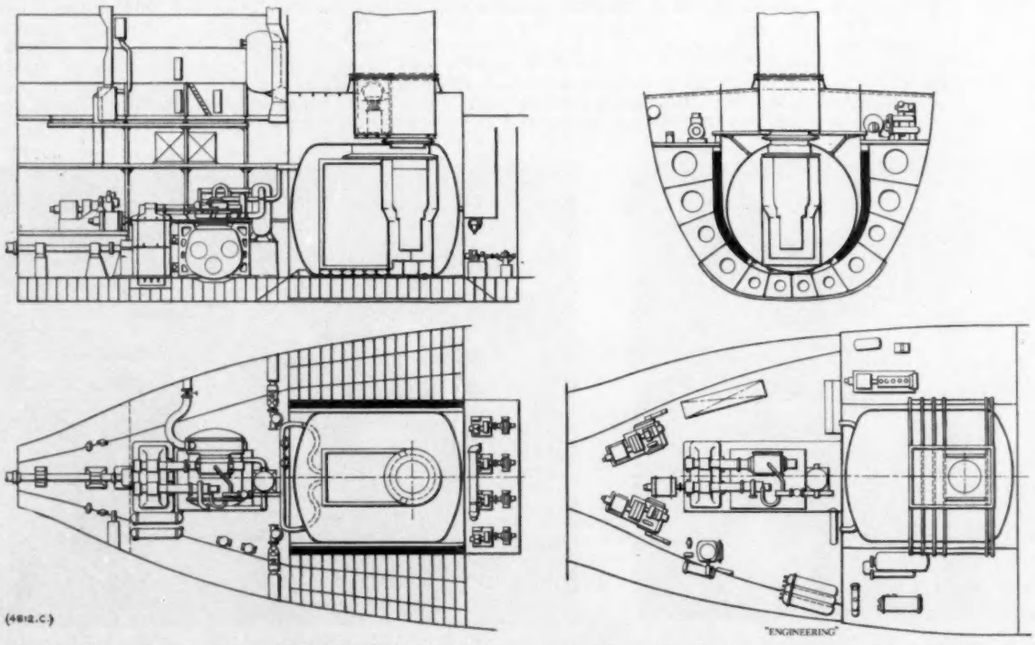


Fig. 2 Machinery layout for a 22,000 deadweight tanker powered by a pressurised-water reactor giving 10,000 s.h.p., showing shielding and containment. The weight is distributed by deep frames to the ship's structure.

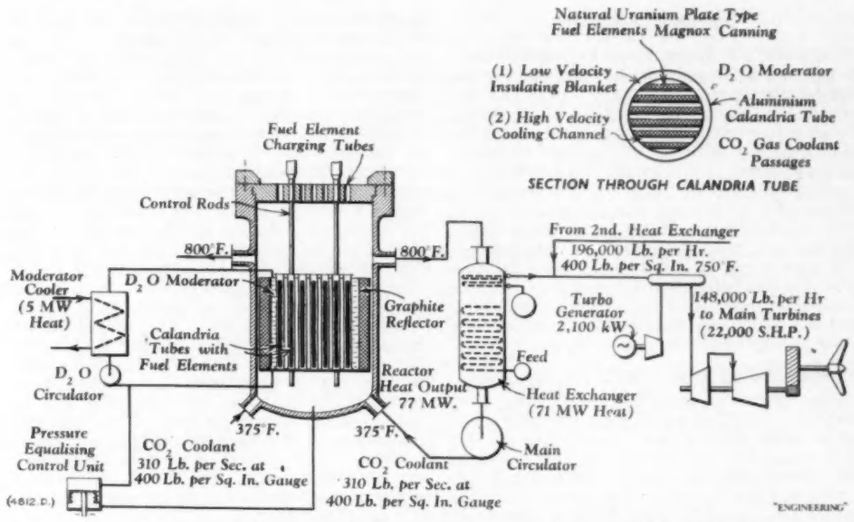


Fig . 3 A reactor system developed in Russia employs heavy water as moderator and carbon dioxide gas as coolant. It may prove a suitable design for shipboard use.

good armour plate against collision damage, particularly as the outermost diameter of the shielding is a considerable distance from the ship's side. Fig. 2 shows a suggested German layout to meet the containment requirement. The cross-section in way of the containment vessel and reactor shows how the weight is distributed by deep frames to the ship's structure.

Pressurised-Water Reactor

The pressurised-water reactor, although established, has almost in one jump reached the limit of its scope, since the permissible pressure controls the temperature available at the heat exchanger. A separately-fired superheater could, of course, be used in conjunction with the heat exchanger to give any desired final temperature. Higher pressures than 1,500 lb. to 2,000 lb. per sq. in. involve welding problems of great magnitude, and pressure-vessel thicknesses exceeding 8 in. In addition, only enriched fuel can be used. It is, however, a compact rugged design suitable for ship, and particularly for naval use, where highly enriched fuel can be made available. It has been used in the " Nautilus," the Shippingport reactor (which is a land-based prototype for aircraft carrier propulsion), " Yankee," and is to be used in the British submarine " Dreadnought," under construction. " Nautilus " has been reported as steaming 69,138 miles during a period of 26 months before refuelling. The uranium 235 " burned " in this period was 2·8 lb. The commercial economy of pressurised-water reactors is, however, low because of high capital cost, low steam conditions, the necessity for enriched fuel and the high cost of fabricating fuel elements. Improvements in rating, thus reducing the core size, are possible, however, owing to the good heat transmission with water cooling.

The pressurised-water system also involves greater hazards than the graphite-moderated gas-cooled system. The high pressure involves greater risk of failure, especially with a volatile coolant, since " flashing " of the water could be a source of serious contamination. Hot water reacts violently with uranium and in the event of failure of the canning material the whole heat-exchanger system would become highly radioactive. Effective shielding of the heat exchanger is also important as the water itself becomes radioactive in its passage through the core. These considerations require a strong containment vessel surrounding both reactor and heat exchangers.

The minimum practical enrichment for a pressurised-water reactor is about 1·5 C_0 requiring the extensive use of expensive materials low in neutron absorption such as Zircalloy. Such reactors will have a fairly large critical size, of the order of 30 tons, and this size can only be reduced at the expense of increased enrichment. Designs for naval applications are optimised for high rating and strength. Considerations of neutron economy are therefore of secondary importance and considerably higher enrichments are used.

Boiling-Water Reactor

The boiling-water reactor is similar to the pressure-water reactor except that it can operate at a pressure of about 500 lb. per sq. in., the pressure being chosen to suit the steam cycle. It has, however, a further undesirable feature in its power characteristic compared with the pressurised-water reactor. A reduction in power causes an increase in pressure which reduces the steam bubbles in the core. This causes an increase in reactivity due to the increase in density of the moderator. The total power output from the boiling reactor is limited as in boilers by the rate of release of steam from the free water surface. It is considered also that the direct passage of steam from the reactor to the power turbine would require all machinery, including condenser and feed systems, to be shielded, and at once introduces problems of remote control and tight shaft seals. If this reactor has to work with heat exchangers, to minimise the shielding requirement, advantages over the pressurised-water type arising from the much lower pressure of operation are greatly reduced.

Organic Moderated and Cooled Reactor

To reduce the high pressures used in the pressurised-water reactor, organic liquids (diphenyls and terphenyls or commercial materials such as Dowtherm) have been suggested. The high boiling point of such materials enables pressures of the order of 150 lb. per sq. in. to be used. The cost is consequently lowered and difficulties in construction of the reactor vessel and heat-exchanger systems are minimised. The liquids appear to be far less corrosive than water at higher temperatures and slightly higher coolant temperatures can be employed. The stability of the liquid under heat and radiation might not be shown up by laboratory tests. Corrosion properties might be affected by contamination with air or steam. Air contamination may occur in the storage tanks, where permissible levels may be one to two parts per million, since corrosion products may have high neutron cross-sections. Steam temperatures from the heat exchanger up to 600 deg. F. (316 deg. C.) should be possible.

Considerable development work is required and the system, like the pressurised-water reactor, necessitates the use of enriched fuel (lowest value of enrichment, say, 1·5C_0). The heat-transfer properties of organic liquids show little improvement over gas and worst of all the stability of the liquids under heat and radiation does not appear to be good. Information published gives the average breakdown rate of polyphenyl materials as 30 per cent. for an integrated flux of 10^{18}. This requires, in a 22,000 s.h.p. set of propulsion machinery, about a ton of make-up and the disposal of about a ton of irradiated material per day as tars. The consequence of a gummed-up heat exchanger could be disastrous. There is also a fire risk in the materials. Just as with the pressurised-water reactor there is a limit on top coolant temperature (although higher) imposed by radiation and thermal stability of the coolant which curtails any improvement in economy which would result from high thermodynamic efficiency. Containment would also be required against " flashing " as in the pressurised-water reactor. If developed as a reactor for other purposes it might be considered for ship use but a special development

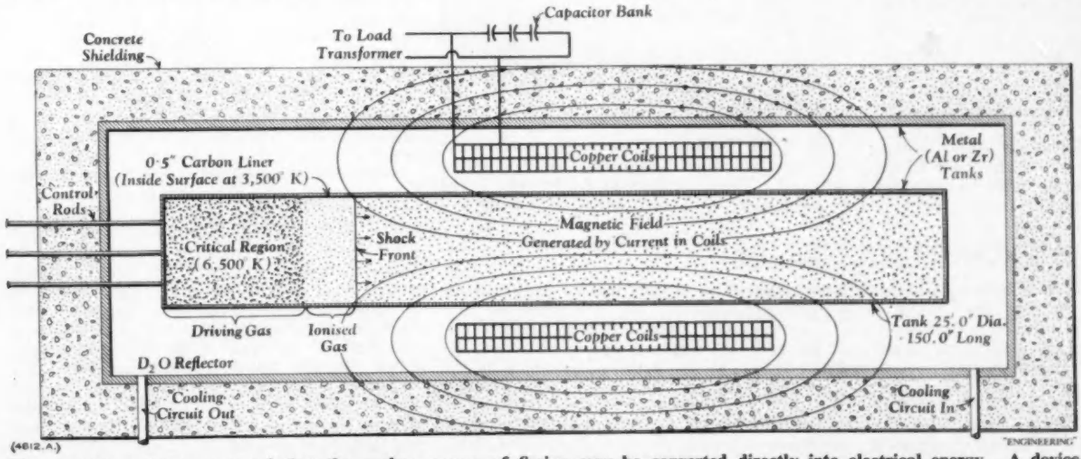


Fig. 4 It has been suggested that the nuclear energy of fission may be converted directly into electrical energy. A device proposed by two Americans makes use of a refractory tube containing uranium or plutonium gas. **(See page 446.)**

as a marine reactor does not appear to be warranted.

Heavy-Water Reactor with Gas Cooling

The last reactor scheme to be described is a Russian development. Heavy water serves as moderator and the heat from the fuel elements is extracted by gas cooling. This reactor, which is shown diagrammatically in Fig. 3, may use natural uranium as fuel and the pressures are those necessary for cooling. The advantages of gas cooling are two-fold, firstly, a reduction in the amount of heavy water required, and secondly, high coolant temperatures leading to an improved steam cycle. The fuel consists of plate-type elements or bundles of rods in a magnox (or beryllium) tube, which is assembled in outer tubes of aluminium. The coolant is carbon dioxide at the same pressure as that in the shell, so that the aluminium tubes do not have any pressure difference across them. For nuclear reasons the moderator must not be allowed to get too hot, and the main problem in design is to prevent too much reactor heat passing to the moderator, leading to an appreciable cycle loss and a dangerous temperature in the aluminium tube (above 230 deg. C.).

General Notes

Withdrawal and Higher Prices in United States

Mr. K. E. Fields, general manager of the United States Atomic Energy Commission, is reported to have told the Joint Congressional Atomic Energy Sub-committee that the American Machine and Foundry Company was withdrawing from an agreement to construct a nuclear reactor for the Rural Co-operative Power Association of Elk River, Minnesota. The company were unwilling to build the reactor for the previously agreed price of 5,686,000 dols. He also stated that the Foster Wheeler Corporation had increased its construction price on another nuclear plant (that at Mersey, Michigan, for the Wolverine Electric Co-operative) from 5,400,000 to 14,400,000 dols.

Uranium Plasma Reactor for Direct Conversion

The direct conversion of nuclear energy into electricity is an attractive idea, and on a small scale steps have already been taken in this direction. The atomic battery, for example, uses the energetic ions from a radioactive source to charge a small capacitor. In a recent article in *Nucleonics* (August), S. A. Colgate and R. L. Aamodt, both of California University, describe a concept whereby nuclear energy might be converted into electrical energy directly and on a large scale. The rating might be 500 MW or more. The principle is as follows.

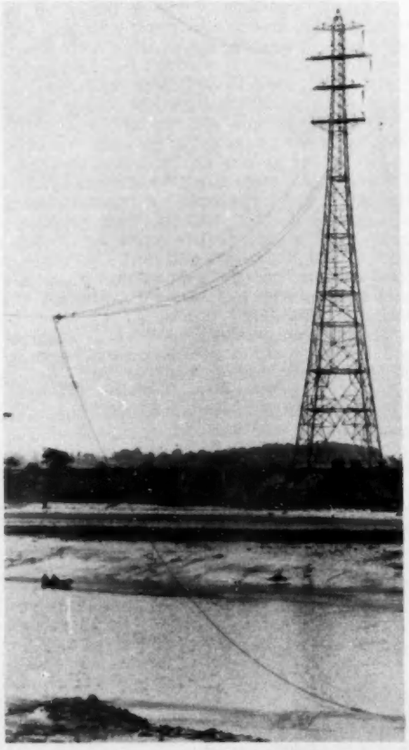
A long cylinder of refractory material with a neutron reflector and moderator at each end, as shown in Fig. 3, is filled with a fissile gas (uranium 235 or plutonium 239) at one atmosphere pressure. The gas when uniformly distributed would be just below criticality. Given an initiating impulse, the gas might be compressed at one end of the cylinder, so becoming critical. The consequent release of fission energy could, if conditions were right, cause a shock wave, which would travel along the tube to compress the gas at the other end. The process would continue indefinitely. Immediately behind the shock front the gas would be highly ionised, so forming a disc-shaped conductor which moves along the tube. If a magnetic field is applied to the system, the effect is analogous to the movement of a conductor through a current-carrying coil: energy of motion is transformed into electrical energy. Current is thus created in the external circuit and can be stored for use in a condenser bank.

Construction

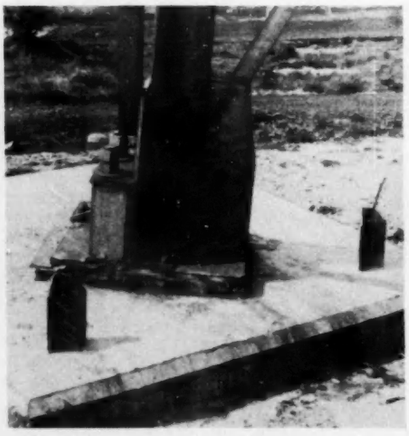
132 KV LINE OVER THE RIVER RIBBLE

Erection Completed in 12 Hours

Stringing a new 132 kV circuit, running from Penwortham to Quernmore and crossing the navigable channel of the River Ribble at Preston, Lancashire, has recently been completed. This circuit, which is additional to the existing six 33 kV and three 132 kV crossings, is strung on double-circuit steel towers leaving a spare circuit for future requirements. The crossing span is 760 ft. and the towers are 240 ft. high, giving a minimum clearance over the river at mean high water of 160 ft. At present the towers carry three 0·175 sq. in. S.C.A. conductors and one 0·07 sq. in. S.C.A. earthwire in suspension clamps, the conductors being tensioned off at short anchor towers, one span beyond each crossing tower.



One of the two 240 ft. high double-circuit crossing towers for the 132 kV line over the River Ribble. The clear span is 760 ft. and the minimum clearance over the mean high water is 160 ft.



One of the footings of a crossing tower. The jacking points are seen projecting from the concrete pile cap. There are four 17 in. diameter bored piles, each 40 ft. long, below each footing.

It was specified that the crossing towers should be designed to withstand a wind pressure of 25 lb. per sq. ft. on one and a half times the projected area of their members up to a height of 150 ft. and 32 lb. per sq. ft. over 150 ft. with a factor of safety of 2·5, and that the conductors and earth wire should be strung to obtain maximum working tensions of 8,000 lb. and 6,000 lb., respectively, at 22 deg. F. with a wind pressure of 12 lb. per sq. ft. on 0·5 in. of radial ice. The ultimate design loads on each footing was 90 tons compression and 140 tons uplift.

Because of poor sub-soil conditions and the high loading it was necessary to pile the crossing-tower foundations and four bored piles of 17 in. diameter were driven to a depth of 40 ft. for each footing, and the base plates were set on concrete pile caps 7 ft. by 7 ft. by 5 ft. 6 in. deep. In order to allow for final adjustment of the base plates when the first section of the tower had been erected, two stub-angle jacking-points were set into the top of each pile cap, the holding-down bolts passing through over-sized tubes set in the concrete. The whole assembly was grouted in when the correct diagonal and rake measurements had been obtained.

The co-operation of the Port of Preston Authority was required to obtain interruption of navigation while the conductors were taken across the river and sagged, and it was finally agreed that river traffic could stop on two successive days for a period commencing two hours after high water and finishing two hours before the next high water. This gave in all a total of about 14 hours in which to complete the work without hindrance from passing vessels.

Since it was considered undesirable to pull the conductors through the water it was decided to pay them off braked drums set at the base of the southern anchor tower and take them through sheaves on the cross-arms of the adjacent crossing tower, pulling them under tension across the river by means of a wire rope attached to an ex-Service balloon winch on the north bank. The wire rope was initially pulled across from the north to the south bank by a small boat, hired for the occasion. The earthwire was successfully pulled across first, to be followed by the three conductors attached to a yoke devised to prevent them twisting together and damaging one another.

After the conductors had been landed on the north bank they were taken up through sheaves

RUNCORN-WIDNES BRIDGE

The tender for the Runcorn-Widnes road bridge has been let to Dorman, Long and Company, Limited, Middlesbrough. The structure (which was illustrated by an artist's impression in our issue of May 4, 1956) has a main steel arch of 1,082 ft. and side spans of 250 ft. each; next to the Forth Bridge it will contain the largest bridge span in the United Kingdom. Much of the superstructure will be of high-tensile steel and in general is to be of riveted construction, though certain portions of the deck will be welded. Some 5,600 tons of steel will be used and the whole contract is worth about £2,000,000.

The reinforced concrete approach works will be let to Leonard Fairclough Limited, Adlington, Lancashire, who have been engaged on the construction of the foundations. They began this work early last summer and the foundations to the main bridge are now about 80 per cent. complete. The consulting engineers are Mott, Hay and Anderson, 9 Iddesleigh House, Westminster, London, S.W.1.

on the crossing tower in a similar fashion to the southern tower and then pulled through to the north anchor tower by a crawler tractor. The compression dead-end clamps were made off at the north anchor tower, and the conductors sagged from the south anchor tower and landed with an hour or so to spare before the first ship of the day passed under the crossing.

The work of running and sagging the crossing section was further complicated by the fact that there was a crossing of a 33 kV double-circuit line on steel towers traversing the northern anchor span. But thanks to the co-operation of the engineers of the No. 4 Sub-Area of the North Western Electricity Board it was possible to drop the conductors of the 33 kV line to the ground, so enabling a light scaffold to be erected over them and the crossing to be executed with the least difficulty and therefore in the minimum of time.

The main contractors to the C.E.A. included British Insulated Callender's Construction Company, Limited, London. The towers were designed by Blaw Knox Limited, and the piling sub-contractors were Pressure Piling Company (Northern) Limited. Kennedy and Donkin, 12 Caxton-street, London, S.W.1, were the consultants, and Mr. C. E. Woodhead, A.M.I.E.E., of their Manchester office contributed the above article.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Push Button Housekeeping," by Mrs. M. E. Pickford. North East London Branch. Angel Hotel, Ilford. Mon., Oct. 7, 8 p.m.
"Wiring Systems." Open Debate. South West London Branch. Prince of Wales Hotel, Wimbledon, S.W.19. Thurs., Oct. 10, 8.30 p.m.

BIRMINGHAM
"Plastics in the Electrical Industry," by S. F. Sandford and W. E. Downing. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Wed., Oct. 9, 7.30 p.m.

HALIFAX
"Some Aspects of Street Lighting," by J. H. Mollan. Halifax Branch. Crown Hotel, Horton-street, Halifax. Wed., Oct. 9, 7.45 p.m.

LEEDS
"Radiations for Diagnostic and Therapeutic Purposes," by A. E. Holland. Leeds Branch. Great Northern Hotel, Leeds. Mon., Oct. 7, 7.30 p.m.

PORTSMOUTH
"Safety in Electrical Installations," by S. J. Emerson. Portsmouth and District Branch. Wiltshire Lamb Hotel, Portsmouth. Tues., Oct. 8, 7.30 p.m.

SHEFFIELD
"Automatic Heating Controls," by G. C. Fox. Sheffield Branch. Royal Victoria Station Hotel, Sheffield. Mon., Oct. 7, 7.30 p.m.

STOKE
"Earth Leakage Protection of Domestic and Similar Installations," by J. A. Robbins. Stoke and Crewe Branch. Grand Hotel, Hanley, Stoke. Fri., Oct. 11, 7.30 p.m.

YORK
"Switchgear and Motor Control Gear," by J. F. Cummings. York Branch. Royal Station Hotel, York. Tues., Oct. 8, 7.30 p.m.

British Institution of Radio Engineers

GLASGOW
"Reception Problems of Scottish Television," by W. Boyd. Scottish Section. 39 Elmbank-crescent, Glasgow, C.2. Thurs., Oct. 10, 7 p.m.

NEWCASTLE-UPON-TYNE
"High-Fidelity Loudspeakers," by R. A. Bull. North-Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Oct. 9, 6 p.m.

WOLVERHAMPTON
"Transistors—Circuits and Applications," by M. D. Cooper. West Midland Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Oct. 9, 7.15 p.m.

East Midlands Metallurgical Society

NOTTINGHAM
Presidential Address, by N. S. Angus. Nottingham and District Technical College, Shakespeare-street, Nottingham. Thurs., Oct. 10, 7.30 p.m.

Illuminating Engineering Society

LONDON
Presidential Address on "Designing for Harmony," by E. B. Sawyer. Royal Institution, Albemarle-street, W.1. Tues., Oct. 8, 6 p.m.

NOTTINGHAM
Induction of Chairman and visit of President. Nottingham Centre. East Midlands Electricity Board, Smithy-row, Nottingham. Thurs., Oct. 10, 6 p.m.*

Incorporated Plant Engineers

GLASGOW
"Measurement and Prevention of Smoke from Industrial Boilers," by T. F. Hurley. Glasgow Branch. Scottish Building Centre, 425-427 Sauchiehall-street, Glasgow, C.2. Thurs., Oct. 10, 7.15 p.m.

MANCHESTER
"Chain-Grate Stokers," by C. H. G. Hayward. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Oct. 8, 7.15 p.m.
Discussion on "What Purpose does Incorporated Plant Engineers Serve?" Joint meeting with Merseyside and North Wales Branch. Aboard Club Ship "Landfall." Thurs., Oct. 10, 7.15 p.m.

NEWCASTLE-UPON-TYNE
"Manufacture of Tubes," by H. B. Elliot. North-East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., Oct. 10, 7 p.m.

Institute of Marine Engineers

BIRMINGHAM
"Turbo-charging of Two-Stroke Oil Engines," by Rear-Admiral W. G. Cowland. West Midlands Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Thurs., Oct. 10, 7 p.m.

GLASGOW
"Developments and Trends in Marine Field," by W. Young. Scottish Section. 39 Elmbank-crescent, Glasgow, C.2. Wed., Oct. 9, 7.30 p.m.

KINGSTON-UPON-HULL
"Modern Methods of Shipbuilding," by R. S. Hogg. Kingston-upon-Hull and East Midlands Section. Thurs., Oct. 10, 7.30 p.m.

LIVERPOOL
"Marine Machinery Breakdown," by J. H. Milton. Merseyside and North Western Section. Liverpool Engineering Society, The Temple, Dale-street, Liverpool. Mon., Oct. 7, 6 p.m.*

Institute of Metals

BIRMINGHAM
"Production of Wrought Forms in Titanium and Titanium Alloys," by J. R. Crane. Birmingham Local Section. College of Technology, Gosta Green, Birmingham. Thurs., Oct. 10, 6.30 p.m.

SWANSEA
"Pure Metals," by Dr. J. C. Chaston. South Wales Local Section. University College, Singleton-Park, Swansea. Tues., Oct. 8, 6.30 p.m.*

Institute of Road Transport Engineers

BIRMINGHAM
"Use of Plastics in Road Transport," by M. D. Curwen. Midlands Centre. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Tues., Oct. 8, 7.30 p.m.

BRIGHTON
"Wear and Tear," by J. E. Johnson. Southern Centre. Preston Technical Institute, Brighton. Wed., Oct. 9, 7.30 p.m.

BRISTOL
"Free-Piston Gasifier with Special Reference to Vehicle Application," by a speaker from Free Piston Engine Co., Ltd. Western Centre. Royal Hotel, Bristol. Tues., Oct. 8, 6.30 p.m.

CARDIFF
"Operation and Development of Disc Brakes," by T. J. Phipps. South Wales Centre. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Oct. 11, 7 p.m.

CHELMSFORD
"Development and Operation of Disc Brakes," by T. J. Phipps. Eastern Centre. County Hotel, Chelmsford. Tues. Oct. 8, 7 p.m.

EXETER
"High-Pressure and Syndromic Lubrication Systems," by W. T. Kay. Western Centre. Rougemont Hotel, Exeter Fri., Oct. 11, 7 p.m.

GLASGOW
"Exhaust Brake Design and Operation," by A. G. Slee and W. K. Cox. Scottish Centre. 39 Elmbank-crescent, Glasgow, C.2. Mon., Oct. 7, 7.30 p.m.

MANCHESTER
"Trends of Modern Passenger Transport," by R. Cox. East Regional Centre. Houldsworth Hall, 90 Deansgate, Manchester. Mon., Oct. 7, 7.30 p.m.

Institution of Chemical Engineers

LONDON
"Effect of Temperature on Bursting Discs," three papers by H. R. Wright, T. B. Philip, and J. W. F. Brown. Federation of British Industries, 21 Tothill-street, S.W.1. Mon., Oct. 7, 5.30 p.m.

Institution of Electrical Engineers

LONDON
Chairman's Address on "Joints and Hinges," by J. Vaughan Harries. Utilization Section. Thurs., Oct. 10, 5.30 p.m.*

BIRMINGHAM
Annual General Meeting and Conversazione. Chairman's Address by L. L. Tolley. South Midland Centre. Grand Hotel, Birmingham. (Admission by ticket.) Mon., Oct. 7, 6 p.m.

MANCHESTER
"Electrical Floor Warming," by J. W. Moule and W. M. Stevenson. North-Western Centre, Utilization Group. Engineers' Club, Albert-square, Manchester. Tues., Oct. 8, 6.15 p.m.*
Chairman's Address, by K. J. Butler. North-Western Centre, Radio and Telecommunication Group. Engineers' Club, Albert-square, Manchester. Wed., Oct. 9, 6.45 p.m.*

Institution of Engineers-in-Charge

LONDON
Annual General Meeting. Caxton Hall, off Victoria-street, S.W.1. Wed., Oct. 9, 6.30 p.m.

Institution of Highway Engineers

MANCHESTER
Paper and film organised by Ministry of Transport. North-West Branch. Engineers' Club, Albert-square, Manchester. Wed., Oct. 9, 6 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Are the Diesel Engine and the Petrol Engine Merging." Internal Combustion Engine Group. Wed., Oct. 9, 6.45 p.m.*

COLCHESTER
Chairman's Address, "Heat and Power for Industry: Effect of Current Trends in Availability of Fuel," by G. W. Bone. Eastern Branch. Red Lion Hotel, Colchester. Tues., Oct. 8, 7.30 p.m.

GLASGOW
"Impressions of Technical Education in America and Russia," by Prof. A. S. T. Thomson. Scottish Branch. Royal College of Science and Technology, Glasgow. Thurs., Oct. 10, 7.30 p.m.

GRIMSBY
"Design and Construction of Aden Oil Harbour," by J. E. G. Palmer and H. Scrutton. East Midlands Branch, joint meeting with East Midlands Association of Institution of Civil Engineers. Royal Hotel, Grimsby. Wed., Oct. 9, 7.30 p.m.

LEEDS
"Governing of Compression-Ignition Oil Engines," by D. B. Welbourn, D. K. Roberts and R. A. Fuller. Yorkshire Branch. University Chemistry Lecture Theatre, Leeds. Thurs., Oct. 10, 6.30 p.m.

LUTON
Chairman's Address. Luton A.D. Centre. Assembly Room, Town Hall, Luton. Wed., Oct. 9, 7.30 p.m.

MANCHESTER
"Economics of Plant Replacement," by C. W. Griffiths. North-Western Branch Industrial Administration and Engineering Production Group. College of Science and Technology, Manchester. Thurs., Oct. 10, 6.45 p.m.

MIDDLESBROUGH
Chairman's Address. North-Eastern Branch. Cleveland Institute, Corporation-road, Middlesbrough. Tues., Oct. 8, 6.15 p.m.

NEWCASTLE-UPON-TYNE
Chairman's Address. North-Eastern Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Oct. 7, 6 p.m.

RUGBY
"Motive Power on Sea and Land," by T. A. Crowe. Rugby Panel. Lawrence Sheriff School, Rugby. Tues., Oct. 8, 6.30 p.m.*

Institution of Naval Architects

LONDON
"Some Problems of Yacht Measurement," by D. Phillips-Birt. Thurs., Oct. 10, 4.45 p.m.

Liverpool Metallurgical Society

LIVERPOOL
Presidential Address, by J. S. W. Graham. Liverpool Engineering Society, 9 The Temple, Dale-street, Liverpool. Thurs., Oct. 10, 7 p.m.

Manchester Metallurgical Society

MANCHESTER
Presidential Address, by Dr. K. M. Entwistle. Central Library, Manchester. Wed., Oct. 9, 6.30 p.m.

Newcomen Society

LONDON
"Early Steam Engines in Derbyshire," by F. Nixon. Lecture Theatre, Science Museum, S.W.7. Wed., Oct. 9, 5.30 p.m.

Physical Society

LONDON
"Colour and Steelmaking," by Dr. B. O. Smith. Colour Group. Royal Photographic Society, 16 Princes-gate, South Kensington, S.W.7. Wed., Oct. 9, 3.30 p.m.

Pipeline Industries Guild

LONDON
"Pipes as Water Mains," by H. R. Lupton. Lancaster Room, Caxton Hall, adjoining Victoria-street, S.W.1. Tues., Oct. 8, 6.30 p.m.

Society of Chemical Industry

LONDON
"Corrosion Resistance of Titanium," by J. B. Cotton and H. Bradley. Corrosion Group. Wed., Oct. 9, 6.30 p.m.*

Society of Engineers

LONDON
"War Damage Reconstruction Work on Premises of Peter Robinson Ltd.," by I. C. Cocking. Geological Society, Burlington House, Piccadilly, W.1. Mon., Oct. 7, 5.30 p.m.*

Society of Instrument Technology

LONDON
"System for Handling Wind-Tunnel Data," by J. F. M. Scholes. Data-Processing Section. Manson House, 26 Portland-place, W.1. Thurs., Oct. 10, 7 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
East Midlands Metallurgical Society, 57 Derby-lane, Derby. (Derby 40767.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHitehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Liverpool Metallurgical Society, Greenhithe, Grosvenor-road, St. Helens, Lancs. (St. Helens 5879.)
Manchester Metallurgical Society, The Kennedy Press Ltd., 31 King-street West, Manchester 3.
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Pipeline Industries Guild, 7 Iddesleigh House, Caxton-street, London, S.W.1. (ABBey 6925.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Engineers, 17 Victoria-street, London, S.W.1. (ABBey 7244.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

The Human Element

Rumblings of Discontent

The General Council of the Trades Union Congress made it clear in a public statement last week that they recognise " the importance of maintaining international confidence in sterling " but that they disagree with the Government as to both the causes of the crisis and the proposed remedies. This matter has been referred to the Economic Committee for more detailed consideration.

The General Council's attitude is of the utmost importance to the country, since it will greatly affect the response the Government can expect from union members to their request for co-operation. First, they do not believe that the speculation against the pound has arisen " primarily from the internal situation in the United Kingdom " but that it has its roots in the international economic situation " in which the policies of several leading countries are involved." Secondly, they consider there is no evidence that " the level of international activity is higher than is desirable in that manpower and other resources are generally subject to undue strain." Their fear is that the measures recently announced, the core of which is a directive to the banks to restrict overdraft facilities to the average level of the past twelve months, will prevent the country from reaping the capital benefit from capital investment of recent years. Thirdly, the General Council criticise the Government's reliance on monetary methods of restriction on the grounds that " these methods are indiscriminate in their effects on investment." There could be no clearer indication of no confidence. The fear is that employment will fall but that productivity will not rise.

To See the World

An announcement in the French Railway magazine, *La Vie du Rail*, gives details of facilities for cultural exchanges with other countries. S.N.C.F. personnel who are registered for this purpose are invited to send their children abroad under the scheme organised by the French Bureau des Echanges Culturels et Séjours à L'Etranger. Travelling abroad during school holidays has become very popular with French children and the Bureau has not therefore lacked applicants. The magazine points out that the facilities open to girls for learning languages by taking up " au pair " jobs as nursemaids or mothers' helps are not available to young men and goes on to suggest that young railwaymen should take advantage of any opportunities to spend a holiday abroad on an exchange basis.

La Vie du Rail, published by the S.N.C.F. for 50 francs (1*s*.) is an excellent example of successful public relations within a nationalised undertaking. It sets out to give information on technical developments in railway engineering, particularly outside France and has a lively technical correspondence column.

Years of Discretion

The problem of an ageing population is rapidly becoming a personal one for most employers. In 1911, three years after the Asquith Government's Old Age Pensions Act, there were 2¾ million men of 65 and over and women of 60 and over; by 1951 the figure was 6½ million, and in 1977 it will be nearly 9½ million, or nearly one fifth of the population. In the circumstances it is important to provide suitable employment for the old, or to raise productivity to such an extent that they will not need to work. The country's manpower needs, in order to purchase from abroad its requirements of food and raw materials, are unlikely to fall significantly during the next two decades. The problem is therefore likely to be to discover how to prolong the effective working life of the average man and woman.

The attitudes of companies to employing older people are therefore of considerable importance. They are reviewed and analysed in an article, " A New Deal for the Over 40's " by Mr. Deryck Abel published in the September issue of the British Institute of Management's Journal, *The Manager*. Mr. Abel is particularly concerned with the welfare and happiness of the old, and therefore with retraining and with pensions. Rapid technical change creates problems of retraining which can barely be appreciated by the average firm and which will require close attention in the next decade. Mr. Abel quotes both B. Seebohm Rowntree and the Watkinson report to the effect that the contribution of older people is different but need not be inferior to that of their younger colleagues. Concerning pensions, Mr. Abel suggests that pension rights under superannuation schemes should not be forfeited when an employee changes job, and quotes the Phillips report of December, 1954, in support. But the major problem is the continually falling purchasing value of fixed pensions. He continues " Unless we end inflation . . . a pension will become a farcical stipend," unless of course it is linked to a realistic cost of living index.

Actuaries or Auctioneers

The Life Offices' Association and the Associated Scottish Life Offices have issued a pamphlet called " The Pensions Problem." It deals with two subjects, the principle of State pensions and the recent proposals by the Labour Party for a national pensions scheme.

So far as State pensions are concerned it points out that these are a means of redistributing the national income in favour of the older generation. This it goes on to say is accepted as good social policy and is not open to challenge, though it clearly does not regard this redistribution to be in terms of purchasing power. It adds, however, that the principle has always been that the State should establish a minimum for everyone and that pensions graded in accordance with some standard are not generally considered to be the State's task. It further points out that such State schemes are not insurance schemes at all but forms of taxation, and should be acknowledged as such.

On the Labour Party's proposals, its line is orthodox. Briefly, it proposes that the plan for national superannuation would be more expensive than is admitted, that it would be difficult to fit private schemes into it, that saving would be discouraged and that plans for an automatic cost-of-living adjustment would be invitations to inflation. Finally, such a scheme, it thinks, would give a grave initial shock to the economy owing to the effect on industrial costs and wages of heavy contributions. In short, it doesn't like the proposals. Unfortunately for the actuaries the issues are ones not of actuarial probability but of political auction.

Professional Let-Down

The case of a hospital board who recently apologised to a bus driver for an indiscreet remark by a medical practitioner is a good example of the processes which are at work these days corroding professional standards. All, including professional men themselves, are caught up in it.

It seems that a doctor refused to examine a bus striker with back trouble as a protest against the inconvenience which had to be experienced by his patients owing to the strike. The man tackled neither the doctor nor the hospital and even refused to accept a note for an X-ray and another appointment. He went straight to his union and complained. The result was the apology.

All parties were at fault. Exasperated as the doctor may have been, he was wrong to let a chance for a protest come in the way of his professional duty. He was, in fact, acting in an unprofessional manner—a serious current danger for the medical profession. The man was equally at fault to refuse further assistance, to go away in a sulk and tell tales to his union. It is not the job of a union to make official protests about professional conduct unless doctors abdicate their professional position for some other status. This is the road that leads to the unionisation of professional bodies.

Easy Come

The start last week by the B.B.C. with school television broadcasts and the announcement recently by the Science Museum of a new series of public lectures are all good examples in their different ways of the awareness of educationists of the teaching value of modern techniques and facilities. They bring the ever-widening intellectual horizons nearer to the experience of the average child. Lectures on scientific subjects go a good deal further. They call for an effort of concentration and an effort by the listener, and are therefore much more in line with the older techniques of education.

It is important to offer better facilities for the average. It is also important to think about those who will be better than average. Modern techniques of the visual sort have their place but they should not usurp the discipline of the written word. No child is going to make a significant contribution to society in most careers unless he can concentrate on written material for reasonable stretches of time. The whole modern trend of published material (from comic strips to pictures in the news) is unconsciously aimed at breaking such a habit of concentration—for adults and children alike. Television may stuff our heads with a variety of useful or diverting information but it will be a long time before it disciplines the intellect.

By Force of Numbers

Last week the Ministry of Works undertook some loading tests on their recently completed footbridge in St. James's Park here in London. It is a very nice bridge in prestressed concrete and from it one has what is reputed to be the finest view in London. A continuous girder bridge over three spans, it has a very slender profile and, in the comparative safety of a footbridge, the Ministry have begun a test on the life of rubber bearing pads which they have used to take up the movements of the deck. Nevertheless—like many county surveyors trying to find enough road rollers to simulate the requirements of the highway bridge loading curve—the Ministry apparently found difficulty in procuring the service of as many pedestrians as would adequately test the bridge. Very properly they resolved the problem by calling in the Army.

Three hundred N.C.O.s and men of the 2nd Battalion Coldstream Guards took part in this live-load test. With a nice gesture of confidence in the designs of the Ministry, the Guards rejected denims as appropriate dress for the occasion but took the precaution of wearing only their " second best " battle dress, albeit with forage caps and with their belts properly—very properly—pipe-clayed. On to the bridge marched the three hundred. They marched, they counter-marched and never once did they break step until, in a last determined effort to prove the bridge for once and for all, the whole three hundred " about-turned " with the three high, crashing steps so beloved by the Guards. Needless to say, the bridge withstood the attack, and all engineers will appreciate the Ministry's reassuring report that " under the load, the bridge deflections were as predicted by their calculations."

ENGINEERING

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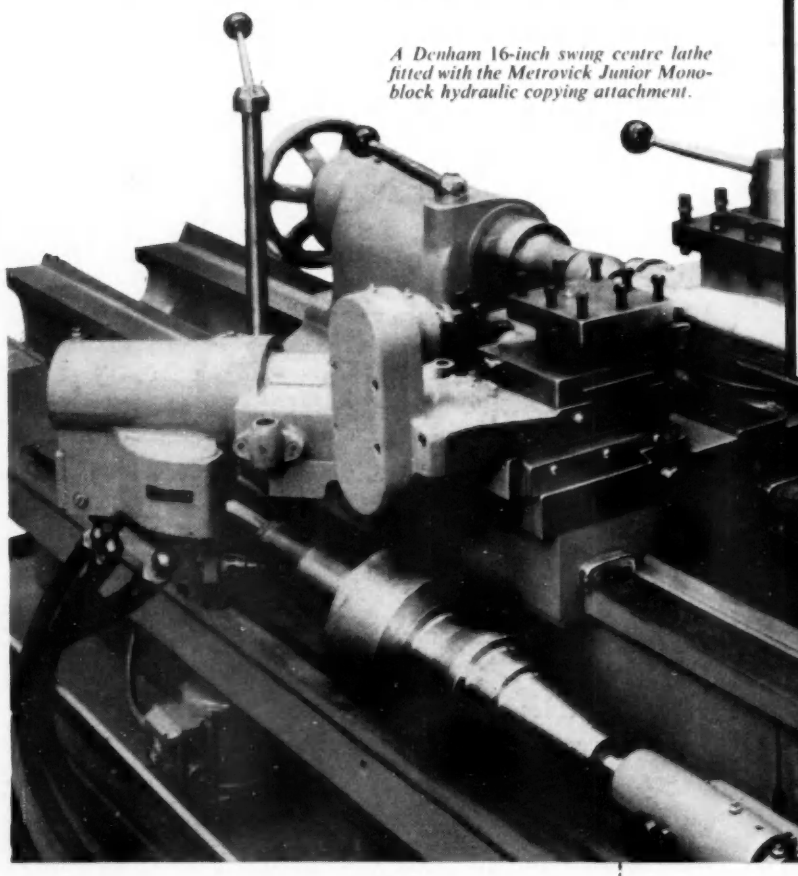

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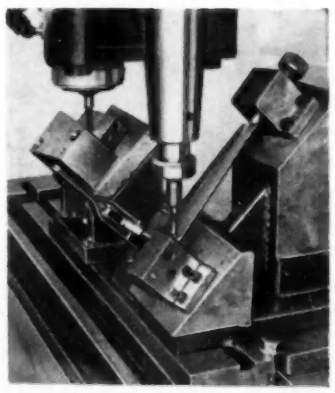

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